EARTH SHELTERED HOUSING WORKSHOP

HELENA, MONTANA
JULY 13, 1978

Transcript prepared by:

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

ENERGY DIVISION 32 SOUTH EWING HELENA, MONTANA 59601

DNRC

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INTRODUCTION

The Energy Division, Department of Natural Resources and Conservation, sponsored a workshop on earth sheltered housing on July 13, 1978 at the Lewis and Clark Library in Helena. Funding for the workshop was provided by the U.S. Department of Energy in support of the planning process for a Montana Energy Extension Service. The workshop brought together architects, engineers, contractors, bankers, appraisers, building code officials and interested citizens from across Montana to discuss a specific topic, earth sheltered housing. This workshop provided the Division with information on the types of questions being asked by and the kinds of services needed by people concerned with the housing industry.

Ray Sterling, Director of the Underground Space Center, University of Minnesota at Minneapolis, and Don Stephens, In Earth Design, Spokane, Washington, addressed the group in the morning. Their presentations and slide shows were followed by comments from a panel of Montana authorities. In the afternoon, the workshop broke into two groups to discuss problems specific to Montana. Sixty-four people registered and an estimated 80 attended the workshop.

The following is a transcript of that workshop. Except in the two places noted, it has been edited for clarity and continuity only. Sterling, Stephens and the panel have reviewed their own presentations for technical accuracy. Also included are a list of workshop participants, and a letter sent to code officials by Jim Kembel, Administrator of the Building Codes Division. The views and opinions expressed herein do not necessarily reflect those of the Department of Natural Resources and Conservation.

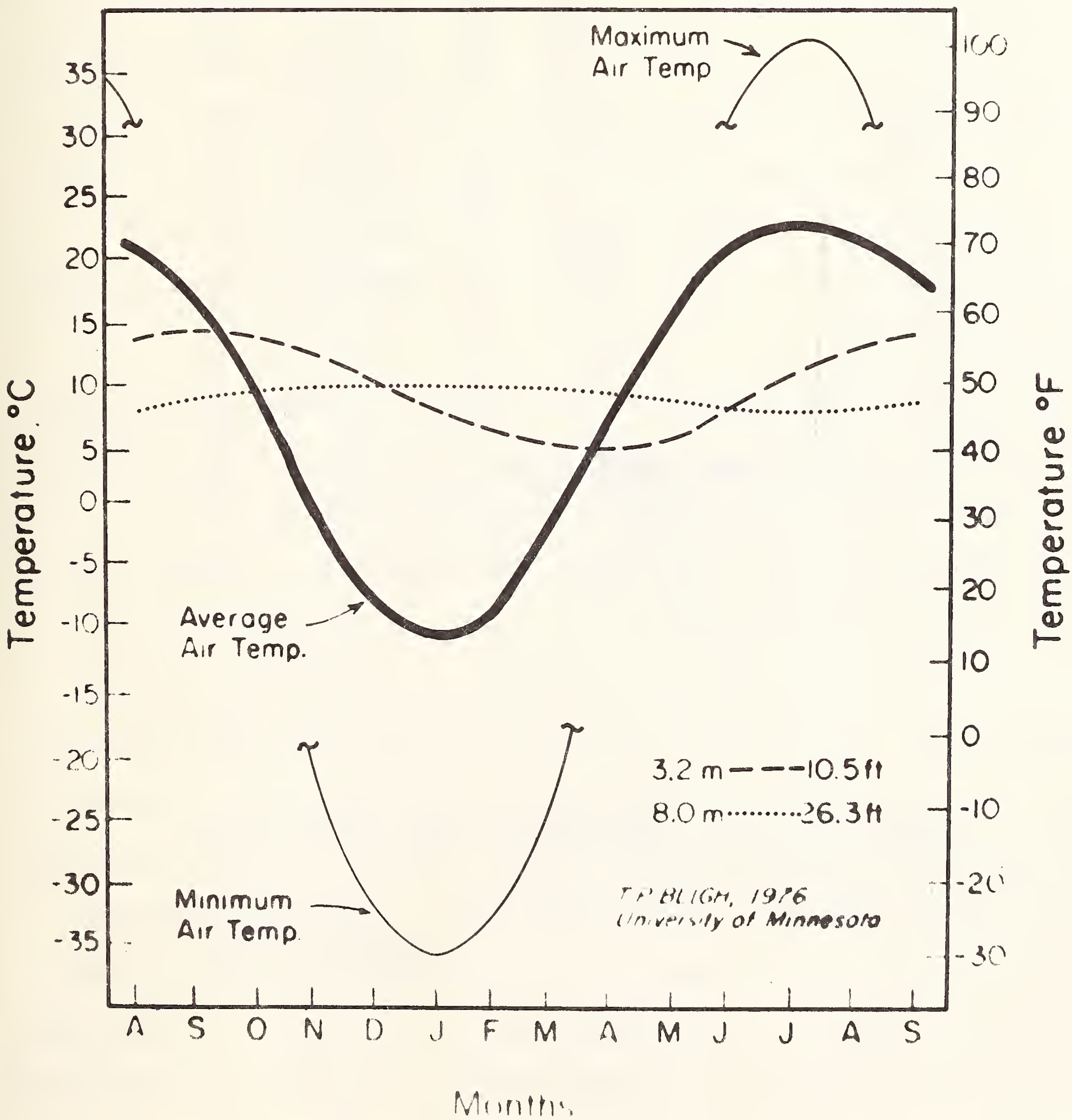
RAY STERLING

(Professor Sterling began with an overview of the energy situation. He argued that the rate of increase in energy consumption could not be maintained much longer, and that this rate could be cut back without necessarily lowering the standard of living.)

If we look at how much energy we are using, we find that somewhere between 25 and 30 percent of the total is used in residential and commercial space heating and cooling, roughly equivalent to the transportation sector. For the colder northern states the figure would be slightly higher than that.

If we look at individual residences we find that, on the national average, a whopping 65% of energy used in a structure goes for space heating and 5% for space cooling. So 70% of all the energy you use in a house is used in just keeping the space in the conditions that you like. How can building underground help? This is a graph from Minnesota where we have very high extremes of temperature, -30 degrees F in winter and over 100 degrees F in summer. That is about 130 degrees F temperature differential from minimum temperatures to maximum. (Figure 1.) The average monthly air temperature is this thick line; as you start going underground you see the dramatic moderation of these temperatures -- ten feet underground you have gone from a 130 degree F temperature swing to less than 20 degree F swing. At about 20 feet underground you find that the temperature is constant, for all engineering intents and purposes. The temperature at that depth is at its warmest in the winter and at its coolest in the summer because the earth responds so slowly to temperature changes. Heat from summer is just getting down there in the middle of winter. People's immediate reaction to that is that if I don't want to build my building ten to twenty feet underground, what would smaller amounts do for you?

Average Monthly Temperature Variation with Soil Depth
Mpls./St. Paul, Minnesota

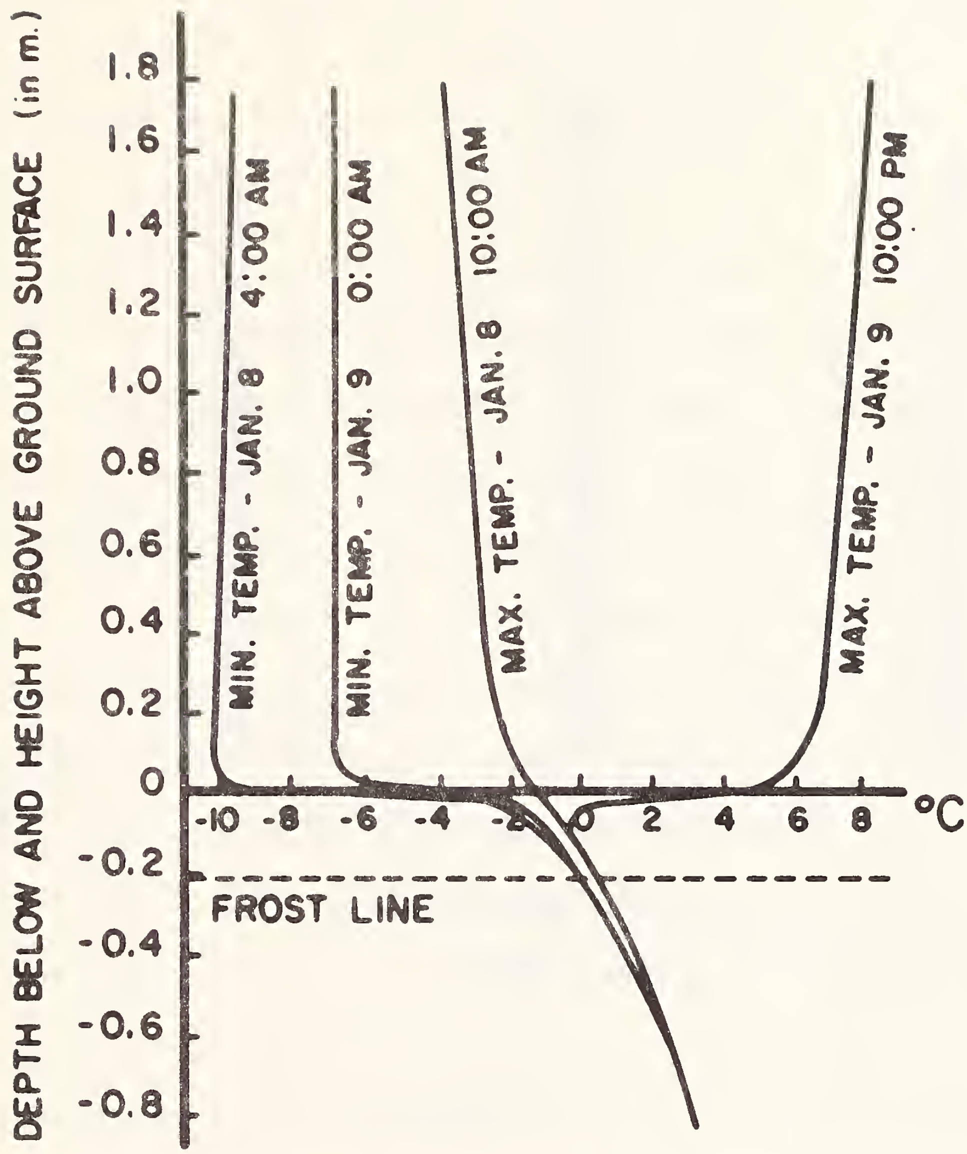


(Figure 1)

These are some data taken in New York on a winter day. (Figure 2.) These represent temperature profiles taken at four different times during about a two day period. The temperature in the air over that two day period went from a minus 10 degrees C to a plus 6 to 8 degrees C. So the temperature swing is from 16 to 18 degrees C. At eight inches below ground level that temperature swing over those two days is almost completely eliminated. This means you don't have to design for short term peaks of heat or cold. You can design your equipment to be smaller in size, which gives some savings on capital investment. Also, it will run closer to capacity for more of its life, and thus run more efficiently.

This slide is a simplification because it doesn't include the ventilation conditions, but in terms of heat transmission above ground you have tremendous heat gain on the roof of the structure. Underground you don't have that. If you have ever stood barefoot on an asphalt roof, as opposed to a grass surface, you will know what the difference can be in surface temperatures. Also, underground you lose heat to the ground around you and that gives you some natural air conditioning. In the winter you have a much higher temperature difference on the outside at the surface; underground you have fairly moderate conditions. You look at the heat flow equations, the normal conduction equations, you find the heat flow per unit area is the U factor times the temperature difference. Above ground you can't do anything about the temperature difference; it is set by whatever the weather is. You can only improve the U factor. In comparison, the earth covering of an underground house is not only not that bad an insulator, but its large mass actually moderates temperature from summer to winter, so it affects both parts of that equation.

Briefly, I would like to mention some commercial applications. This is in the Minneapolis-St. Paul area, large warehouses, windowless, very poorly



MAXIMUM AND MINIMUM TAUTOCHROME, JANUARY 8-9, NEW YORK METROPOLITAN AREA (1956).

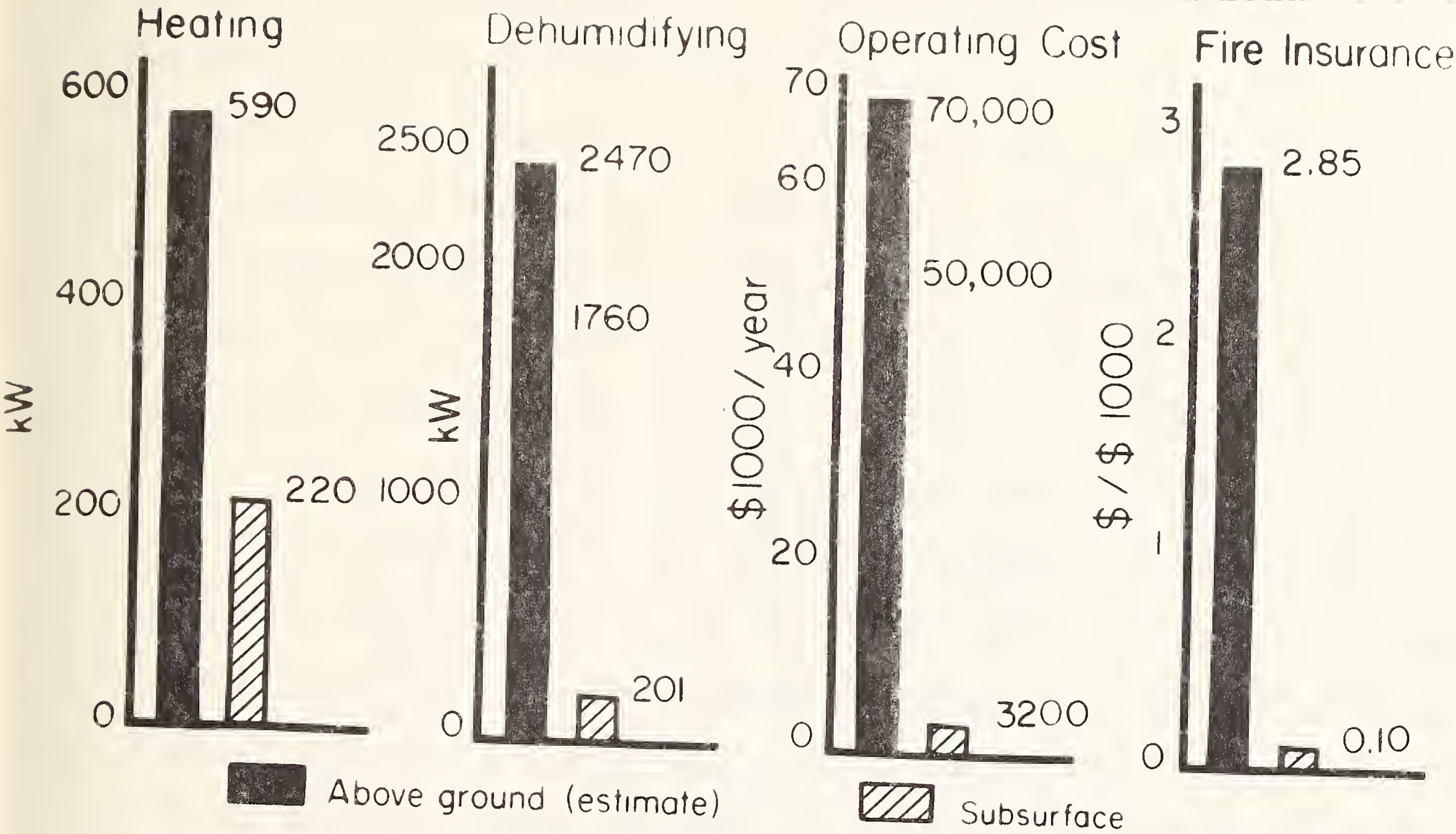
(Figure 2)

insulated and also not making a very attractive landscape. Another much larger facility in Kansas City covers several millions of square feet of industrial and warehousing space, but it is down about 100 feet below the ground surface. Many different organizations have built back in these spaces, which were excavated originally as limestone mines. Now the space is far more valuable than the product they were mining. They are altering their mining practices because of that fact and the mining now is a way of obtaining the space virtually for nothing. These spaces have about 40 foot spans, 13 feet of headroom, temperatures 55 degrees F year around and constant humidity. For this type of dry storage, running costs are minimal.

Here they are creating a foreign trade zone underground. Because of the tremendous security there, they were able to get approval for this. They can take a whole train in there and lock the door on this facility. This particular space runs about a mile in each direction.

The Brunson Instrument Company moved its plant underground to get away from surface vibrations, as they manufacture precision surveying equipment. Their differences in operating costs changed drastically after the move below ground. (Figure 3.) You can see that heating dropped way down, dehumidification even further. Their operating costs dropped out of sight because they are now able to work 24 hours a day instead of just working the small hours of the morning. Their fire insurance dropped to a tiny fraction of what it was before. I would guess they were in a combustible building before they moved.

This is an underground swimming pool, carved into the rock in Norway. This is an underground oil storage in Norway or Sweden; these are enormous caverns. Finland has a ten month supply of oil for the whole country in underground storage. The last oil embargo didn't affect them at all. This is a rock church in Finland, built this way entirely for aesthetic reasons.



COST AND ENERGY COMPARISON OF A MANUFACTURING PLANT

(Figure 3)

This is Place Ville Marie in Montreal. It shows what consideration of all three dimensions of a city can do to tighten up the urban area and enable planners to maintain open space where it is wanted. Montreal is a true three dimensional city; their subway system connects directly into the basements of buildings and passageways. They aren't just narrow dark tunnels, but they have shops and are very pleasant places to be in. Originally, some incentive had to be offered to get the merchants to move in here, but these underground areas are now the most sought after retail spaces in the city.

About 90% of the University of Minnesota Bookstore and Admissions Building is underground. Plantings in the central court, as well as overhangs control the amount of solar gain. The leaves that drop off in winter permit more sun through. This is the lighting effect inside, 26 feet below ground, on the floor level. Many people have remarked that there is actually more light in the public space in the building than there is in most of the other conventional buildings on campus.

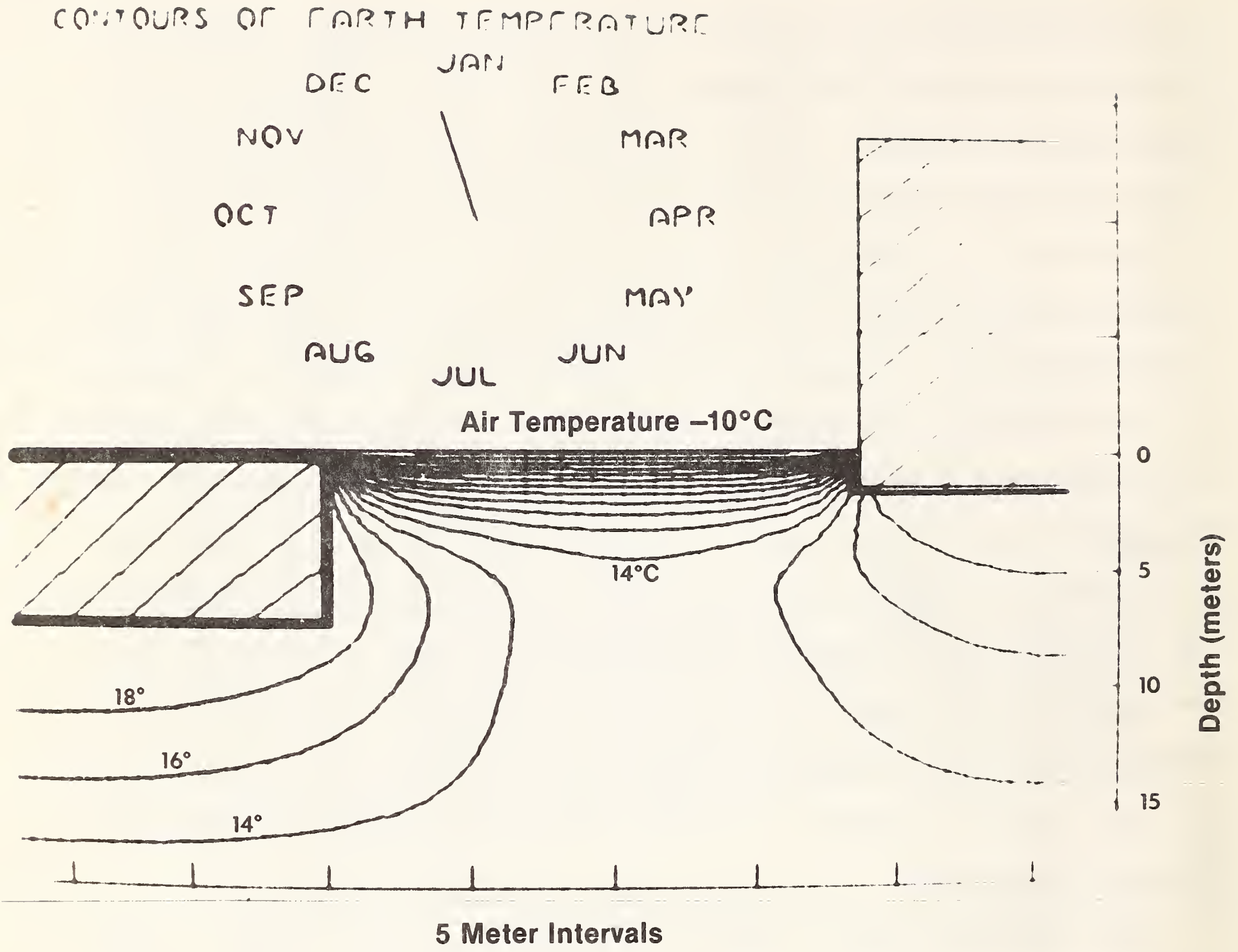
When you talk to people about this building, one of their first reactions is, "I wouldn't want to work underground because I wouldn't be able to see out the window. I want to see what the weather is like." Yet we are building more and more buildings exactly like this building in downtown St. Paul with no windows at all. Dr. Bligh sent some of his students there to do an informal survey. Almost everybody in this building responded that they wouldn't want to work underground. The reason generally given was that they would like to see out the window. Even down in the basement two levels down the people said absolutely they wouldn't want to work underground. So there is a definite negative psychological connotation to working underground.

Some more specific details now. Since we don't have any of this information yet for houses, I'll give you the information on this building, the University

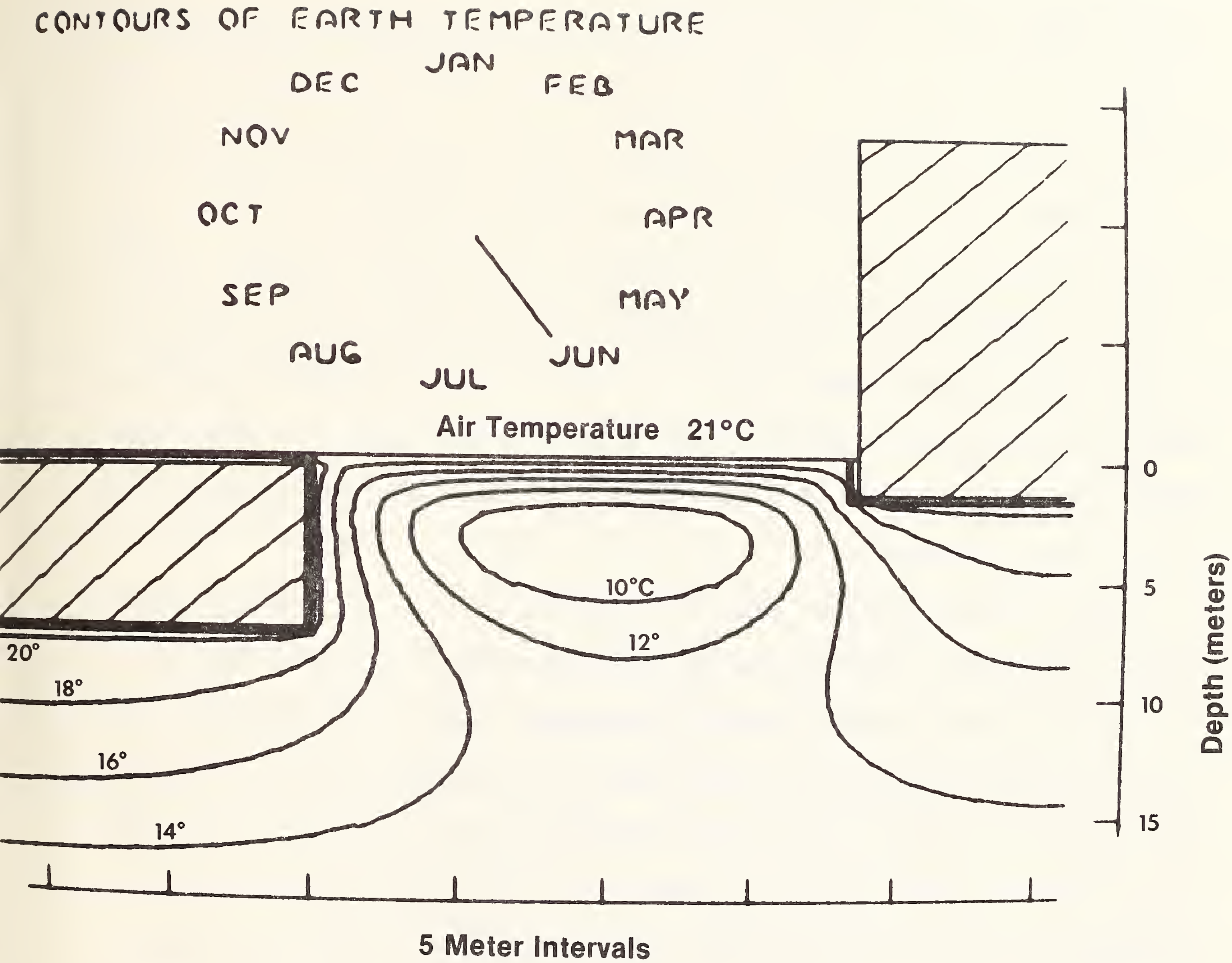
Bookstore, which is still applicable. It's basically a two story building and this represents the building adjacent to it. This shows the temperature conditions modeled in the ground at the end of December, the beginning of January. I don't know exactly what the boundary conditions are -- the temperature up here in the air. The building I think is at 20 degrees C, 68 degrees F. As you come away from the building there are a lot of contours of equal temperature, (2 degrees C), and a very steep temperature gradient into the ground. (Figure 4.) You would say in the absence of this building that the ground temperature of this depth, minus 25 feet, might be 50 to 55 degrees F. However, when your building has been in place three years or so you actually find that it is not until you get many feet out from the building that you get to the undisturbed conditions. All of the area near the building is gradually being warmed up. That is why you can't calculate heat loss by saying I still have 20 degrees F difference between 70 degrees and 50 degrees and I only have a very poor concrete wall or floor to provide insulation. The earth next to the wall or floor eventually will be relatively warm.

The conditions about the middle of May indicate that the ground has warmed up from the surface down, and there is still warmth coming up from underneath. So a cold pocket is trapped in between these two buildings. These temperature lines spread away from the buildings a little. The condition developed a little more in June. (Figure 5.) In August much the same sort of conditions continued. Now what happens as you come on towards winter is that these lines gradually shrink back towards the building a little bit. During the summer you are actually placing heat through the building into the ground, storing it, and getting it back in winter.

This is the thermal conductivity of soil in some lab tests done in connection with the University Bookstore. (The bookstore itself has some heat


CONTOURS OF EARTH TEMPERATURE
JAN
DEC
FEB
NOV
MAR
OCT
APR
SEP
MAY
AUG
JUL
JUN
Air Temperature –10°C
0
5
10
15
Depth (meters)
14°C
18°
16°
14°
5 Meter Intervals

(Figure 4)


CONTOURS OF EARTH TEMPERATURE
DEC
JAN
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Air Temperature 21°C
10°C
12°
20°
18°
16°
14°
0
5
10
15
Depth (meters)
5 Meter Intervals

(Figure 5)

transfer experiments and monitoring going on with it against the moisture content). It is difficult to predict exactly what sort of performance you are going to get from an underground building. Since thermal conductivity in the soil can vary from .2 to over 1.5 with the change in moisture content from 0% to about 20% moisture, you can have a seven-fold variation in thermal conductivity. A fairly small change in moisture content can make a very large difference in the thermal conductivity. In fact, the research has indicated that some of the published values of thermal conductivity of soil in the very low moisture content range may be unreasonably high, in view of the physics of the way it is being measured.

What all this means in terms of housing is that you get a house like Ecology House built in Massachusetts, where they measure energy savings at 60% based on comparison with existing buildings. You can have sunlight in every room; it is extremely quiet and sound proof. The architect mentions construction costs 25% lower than the other sorts of buildings he was building, mainly because of the extremely simple exterior shell. It doesn't require a lot of intricacies in the structure because it isn't seen. It is maintenance free: you never have to paint the walls of your house again. The design is very private and conserves the natural landscape. Housing developments along this line can have up to three times more green areas than conventional ones -- depending on the density of the development.

Now when you are trying to assess the energy performance of earth sheltered or earth covered structures, there is a big difference between designs. The evidence is incomplete, so you can't really talk about how much energy an earth covered building is going to save. One design somewhat intermediate between the preceding two designs shows why we prefer to talk about earth sheltered rather than underground. This building could be considered as an ordinary above ground

building with earth brought up around the back and over the top. When you throw in the passive solar to the buildings, that also changes the energy picture a great deal.

This is a plan of that house; you can see the very simple structural layout. I believe this has about 12 to 15 inches of earth on the roof. The bedrooms are on the front wall, along with the major living spaces. Most of the model building codes around the country require a direct access to the outside from a bedroom. The codes also require a minimum amount of natural lighting into major habitable rooms. Some of the alternatives for ventilation are certain percentages of opening windows or else mechanical ventilation. As you can see the code requirements work out quite nicely with this house plan because the proportion of space which can be put along the back is just about right: the bathroom, storage area, the dining room with a skylight over it, the kitchen receives light from that, and the laundry area is back under the garage. If you want to get a feeling what this sort of space is like, go into a large apartment building which has a central corridor with apartments on either side; they are all one window wall construction and that is essentially what you have here.

The Winston House has wood construction for the roof, heavy timber beams, timber decking, insulation placed over because the owner only had a small amount of earth (you can't rely on the earth for insulation in small depths) and then the waterproofing was put over the top. This detail shows a cantstrip at the overhang, so that you grade out your soil cover over the overhang. You still have the full amount over the ceiling, so you don't get into the frost heave problems on any parapet walls; the lower detail shows insulation around the perimeter so you don't get short circuiting of heat losses through here; just ordinary block construction here and with the rest pretty conventional.

This is the view of the Barnard house in Massachusetts during construction. This is the precast concrete plank which a lot of people, particularly in more developed areas, are using for the roof cover. Here the vents are brought out of the side walls so that the roof is one surface, completely open, easy to waterproof. Over the openings are steel beams which support the ends of the concrete planks and just simple reinforced concrete walls for the walls.

This is one section of the Dune house in Florida. It is a much more efficient structure in terms of holding up earth loads but because of the complexities of designing and forming a curved shell shape like this, it will not prove to be a tremendous amount cheaper. On a multiple unit basis, you could set up an inflatable type of repetitive formwork. Then this type of structure will become increasingly cost effective because you would only have to design the formwork and the shell once. This is a plan of twin units of about 750 square feet each that have a downstairs and then just a loft area with a bed. They are actually designed as beach cottages.

The next house is also a shell structure. The house at River Falls, Wisconsin, is constructed of steel culvert shapes. It's sprayed inside with urethane foam, and covered with another product which is slightly fire retardant. That particular method of construction wouldn't be approved now, but I believe there are products that you can cover with urethane foam to make them acceptable for interior use.

This is a horizontal shell form of a house. This was under construction, basically being owner built. It is going to be a two story structure using silo blocks for the walls of the house and the walls will thrust against these vertical beams here which will be tied across the first and second floors of the house.

This house, the Preusser house in Zimmerman, Minnesota, is going to be

pretty well completely covered over, with openings on the sides except for the north. Wherever you have an opening, you have to have these wing walls down to hold back the earth. In this case this part of the structure will be completely earth covered. I believe this could create design problems because they will need about eight to nine feet of earth fill in a sort of triangular loading on top of the roof of the first section, which means very heavy construction will be needed. The people who are building this house didn't want to go underground and leave their dog with a surface home -- so that is the only earth sheltered dog house I know of.

This is a house, 2000 square feet, in Taos, New Mexico. Here they have sloped the roof beams down from a peak which gives it that feeling of blending right into the surrounding landscape.

This is getting on into some more technical details on the design of the wall systems. Basically, the earth pressure increases with depth, so when you build two stories you have much larger earth pressures on the bottom story. There are two ways of designing the wall: First, a continuous span-over, using the intermediate floor as a support to the wall. That enables you to design the wall a lot more efficiently but it also means that you have to design the intermediate floor to carry some quite heavy loads. Or you could design the wall as two independent units, but you will have a very high loading on that bottom wall.

This shows a little of what I was talking about, if you use the roof or the intermediate floor as a support to the wall. In a typical earth sheltered house design you have an open side along one side of the building. Now with the earth loads that push on opposite sides of the building they can be braced against each other right through the floor. That doesn't create any problem. But when you look at the earth loadings on the back wall you have

nothing equal and opposite to push on the front wall, so these loadings have to be transferred out by the floor in what is called diaphram action, and the reactions to that force come in the side walls. So the intermediate floor has to be designed to transmit these shear forces out to the side walls. That in a two level design can make it very difficult to design the intermediate floor in wood.

Now let's talk about drainage and water proofing: the first thing to do is to stop the water from getting around the house. That means swales around the back of the house. If you can't do that, the more preferable arrangement, you can have some kind of cutoff trench with a drain. If you are building into an essentially level site, drain off to the back. A depressed court is a fairly small area and it isn't going to hurt you too much in catching water but if you have one where the slope continues up from the edge, you will be catching the rainwater from miles around. You want to make sure that the water drains well away from the court or house.

You need to know about dampproofing, waterproofing methods: there are a lot of advantages and disadvantages to different products. Basically, the cheapest product that works is the best product, but you never know what that is before you start. When you are building living space below ground you want to be very confident that it is not going to leak. I would recommend going with some of the better products, which may be expensive, but you are more certain that they are going to do the job.

There is another system which hasn't received an awful lot of testing but has received some research in Sweden. It uses a gravel backfill leading from the foundation drain so that you are preventing any water pressure from coming on the building. You will allow a little freeboard so that if the water does rise during a storm, it won't come in. Basically, then you are isolating the

soil from the wall with a rigid open fiber insulation sheet which will both give you insulation and will also prevent any capillary action from drawing moisture from the soil into the walls. Also, the house is usually warmer than the soil and so the vapor transmission goes outward from the warmer area. This Swedish system also enables you to dry out the wall faster after construction so that is a technique I think has a lot of promise in the future.

A little bit more on different ways that you can design and meet the codes. An Elevational Design, with one side open, is a very compact plan -- you have unbroken earth cover around the other three sides, you have passive gain on one -- a very efficient plan.

The Atrium Plan, in this case a U shaped courtyard, gives the living spaces with natural light and all the rest but your circulation paths have increased tremendously. You have to leave space for people to get around and also your plan is fairly strung out. The surface area of the whole building is greater than on the last plan. It is more visually interesting than the Elevational Plan. It has these openings wherever you need them, and in that respect it is most similar to a conventional house: it has windows all the way around. But every time you make an opening adjacent to these walls you not only bring the cold in, but you also diminish the effectiveness of the earth cover on either side.

This is the last house slide that I am going to show -- Davis House in Arlington, Illinois. He built this himself for $15,000. It has 1200 square feet. The first winter the home was heated solely by burning 2½ cords of wood in a Franklin Fireplace. In the middle of the 76-77 winter, he let his fire go out as they had a bit of snow and it wasn't particularly easy to get to the woodpile. He left his stove out for four days and in those four days in -20 degrees F weather outside the temperature in his house only dropped from 70

degrees F to 62 degrees F. This is only the initial temperature drop, towards an earth temperature that is slightly lower. As it gets closer to the earth temperature that rate of fall will be slower. During the same period that he did this with his house, power went down in some conventional houses nearby. Because their rate of temperature fall was faster they were down below freezing within a matter of hours, water lines burst, and people had to move out to local gyms. In areas like Minnesota or the northern states which have severe conditions in winter an earth sheltered house can change the question of heating in the winter from a survival question to a question more of comfort. As well as the overall amount of energy you use, I think that is a very key factor.

AUSA (American Underground Space Association) is a national association. It produces a journal on underground space which came out four times a year its first two years and it is going to a bimonthly journal in the third year.

My own position is director of the Underground Space Center at the University of Minnesota, funded by the state legislature as a research and information center, and a coordination point with the state for underground construction. This is our mascot Freddy. Animals for a long time have found the place to go in winter is underground.

We have a number of research projects going. The first of these was to complete the book, Earth Sheltered Housing Design. It is available from the American Underground Space Association, and there is a number of flyers that you can pick up at the back which have order blanks on them. A couple of the other projects we have are: State of Minnesota has funded $500,000 for a demonstration earth sheltered housing program. We will build eight earth sheltered houses in the state: three in state parks for park managers, and five built by builder-contractors to be sold on the open market. These will all be held open for a period of at least four to five weeks so the public can see

them in a sort of coordinated open house program; then they will be monitored by the Underground Space Center for a minimum period of a year and a half. So we can get very good quantitative data of just exactly what we can expect in energy use. We also have a study with the Department of Housing and Urban Development to investigate code and financing problems with earth sheltered housing. Basically, we are going to be doing surveys of individual state building code divisions, a sampling of local jurisdictions in each state, some banks in each state, and also as broad a range as possible of individual owners who are trying to build earth sheltered houses to find out what problems they are running into. It is not enough to know just that there are problems in a certain area; you also need to know some of the details connected with them. Then you can make some recommendations on how these problems might be eased.

The final program I would like to mention is an interactive graphics program. There is a real need in this area to predict, before you build, how much energy a house is going to use and what effect changes in design are going to have on energy consumption. We're trying to build up that capability as well.

Thank you very much.

DON STEPHENS

(Mr. Stephens began by describing his background. He was trained as an architect and became interested in earth sheltered housing as a place to retreat from the various urban crises which seemed impending. He later designed over forty secluded structures for "retreaters," all of them at least partially earth sheltered. At present, the bulk of his work is for people who simply wish to have energy efficient housing. He illustrated his talk with his own slides, and with slides prepared by David Scott, Washington State University.)

As Ray Sterling pointed out with his prairie dog slide earlier, earth-sheltering is just learning from nature what lower animals were doing long before man dropped out of the trees. Such creatures for eons have been utilizing the earth as protection from extremes of both heat and cold. The desert tortoise pictured here is one of my favorite examples of this because although cold blooded, he burrows in to escape from temperatures well over 100 degrees in summer and far below freezing in winter. He lives in the American southwest deserts and digs himself a burrow up to thirty feet long. This excavation slopes down near the entrance and then heads upward into the bank to prevent flooding of his sleeping chamber. His daily travels are sufficiently limited that he can return to his shelter whenever weather extremes require. Using these techniques, his species has survived virtually unchanged since the time of the dinosaurs while many of their nonburrowing neighbors met extinction to fluctuating climatic conditions. One can hardly question that earth-sheltering has proved itself as a survival tool.

People too have faced this climatic challenge to survival and, in a number of instances, met it by digging in. This photo is an example of an ancient but still occupied city in the Near East carved from the soft stone of the

mountains and providing shelter from otherwise intolerable extremes. In such stone it was possible to carve out just about any space desired. One such city accommodates over 2000 people in dwellings connected by several miles of tunnels and encircling a number of verticle light shafts. Though begun long before the advent of electricity, air conditioning and central heating, such communities have thrived where only their approach provided proper adaptation to the severe environments in which they were sited.

Montezuma's castle in our own Southwest is another ancient example of sound application of energy conserving principles. In addition to the protection provided by thick adobe and stone walls, it takes advantage of sheltering from rain and harsh winds, proper sun orientation and overhang to provide solar heating in winter with summer shading, minimal exposed wall surfaces and the like.

Here we see a Mandan Indian lodge from our Midwest. The Mandans could no doubt have taught us a great deal about underground construction for survival on the northern prairies had we not decimated their numbers by providing them with blankets contaminated with smallpox!

However, the pioneers moving onto the plains did adopt some of this otherwise lost technology. It's rather ironic that when they first staked out homesteads and were too poor to purchase materials for a surface dwelling, they build soddies from prairie topsoil. Often these were nestled at least partly into the earth for protection against gales which could sweep across that open land. Families lived rather comfortably in such a fashion for several years, enjoying cool in summer and winter warmth without excessive demand for fuel. But when their cash crops began producing, they wanted to upgrade from the soddie with its socially unacceptable image, so they hauled in materials, often from great distances, to construct clapboard saltboxes, like the ones they had left behind on the east coast. In these they froze all

winter and baked all summer, yet gave little thought to returning to the earth. The Mandans might have held little respect for their pride-blinded white brothers who insisted on living so much out of harmony with nature.

This thick-walled adobe house in Baja California is of recent construction but although mostly above ground still gains from the moderating earthmass it uses to absorb heat by day and reradiate it inward at night.

This beautiful mountain meadow introduces another of the reasons for considering earth sheltering. Thoughtless surface construction is not only wasting the limited energy resources of this country but despoiling its fragile beauty as well. Thinking like too many of today's developers, we can see that we could run a road right down the middle of the open space and slap in 75 or 100 "ranchers" on each side; cut down any trees that get in the way and replace natural growth with lawns and property line fences. We'd end up with what all too often passes for "civilization" but lose one more precious piece of nature. The alternative would be to provide vehicular access back in the trees on each side, build low impact earth-sheltered homes looking out on naturally planted open space and retain much of the original delight of this unique site. Earth-sheltering may be our one best answer to finding a middle ground between growth and conservation.

It's long past the time we should decide which we want: construction in harmony with nature or a paved over world full of ticky-tackies in rows or circles or whatever, all looking just the same and bleeding the last of our energy resources into the increasingly polluted air.

Trying to get young minds out of the conventional molds so they can seek more imaginative solutions to our environmental problems, David Scott, Washington State University, developed the teaching tool you see pictured here which illustrates the five possible positions of structure in relation to earth surface.

From left to right we see the cube raised on stilts above the earth, the cube sitting on the surface, partially set into the ground, inset up to its roof and finally with its top well below the surface.

The next slide shows the contrast a bit more architecturally. The two design concept models depicted were developed by students at WSU. On the right is the now familiar geodesic dome shell structure enclosing a maximum of space with a minimum of materials and standing nude on the surface, completely at the mercy of the elements. On the left the same amount of space is incorporated in a subsurface design providing the thermal and environmental advantages previously discussed.

This Collins' well water isotherms map of the United States shows well water temperatures in various regions, an indicator of earth temperatures at depth. Of course, as you approach the surface there is increasing fluctuation but it tends to be rather evenly distributed around an average consistent with deep soil readings below it. You may note that sites everywhere but the southernmost parts of Florida and Texas offer natural air conditioning potential by allowing the coolness of the soil to draw heat from the building from below. In Montana where soil temperatures are far cooler on average, some insulation is in order to prevent undue loss; however, even where the soil temperature is 37 degrees, that beats the topside -10 degrees with a wind chill down to -60 degrees or more on many winter days!

Based on the above and other factors, this second map prepared by Langewieshe for a 1950 HOUSE BEAUTIFUL acticle, shows those areas he feels would be varingly appropriate to underground construction: area 1, including most of the West, Midwest and Northeast would be optimum for each approach; area 2 would be less desirable by his standards and in area 3, limited to the Southwest desert and the humid Southeast, he feels such an approach would offer no benefit. However,

I would tend to disagree based upon my differing view of benefits. In some of those three regions, earth-sheltering would be most functional as protection against hurricanes or other weather extremes or wildfires as well as to preserve scenic values. In any case, there is little question of the appropriate nature of earth-sheltering in the inland northwest!

Getting back to the environmental issue, one can take one or both of two stances. You can use earth-sheltering to preserve a beautiful natural site as we discussed earlier or start with a place that has been despoiled already and restore it by going underground and earthing over to reconstruct the natural state of the site. Malcolm Wells, one of our leading proponents of terractecture, has been a strong advocate of this latter approach for several years. This slide depicts in cross section a project of that type with which I was involved. The client had acquired an old gravel quarry which we used as a free excavation, thus saving on cost. We used native stone for columns and other surface treatments to carry through the theme. The part of the pit not used for the house was planted in garden and produces bountiful crops. Because the pit was in black basalt, its sides tend to absorb and reradiate heat, providing more moderate temperatures and a longer growing season than the windswept surface above.

Returning to the other alternative of preserving unspoiled sites, I know of few places in this country more beautiful than many parts of Montana, but let's face it, there are some of the "developed" parts of your fair state that could hardly be described as other than ugly. Indeed, there is too much of the inland Northwest which could be shipped to Los Angeles without seeming out of character there and that's no compliment! So, if we can propose construction alternatives which will preserve the beauty which remains while better meeting the needs of the people, then perhaps in time, as consciousness increases, we can also remove or replace those existing buildings which can be best catego-

rized as eyesores. This is a goal I'd like to share with you today.

However, I don't want to imply by this that I feel all architecture should be buried. There are certain structures which, tastefully designed, would be appropriate and delightful to experience on the surface. But when you look around and ask yourself what part of present construction would be missed if hidden from view, I fear the percentage worth looking at is pretty darn small. I've heard it said that architects who can't create beautiful buildings should design inoffensive background architecture. I would ask instead if that which cannot in itself enhance the scene should not perhaps be placed under it.

This next series of diagrams outlines the several basic approaches to underground construction. The first is completely subsurface in a vault or without skylighting. This concept grew largely out of nuclear war fears of the sixties. A number of houses of this type have been constructed in Texas, where each room has its own view painted on the vault wall outside a conventional window and time of day can be controlled by manipulating a series of reostatic light switches. In this way it may be morning outside the kitchen, afternoon in the den and sunset outside the master bath. Such an approach greatly appeals to a few but is most unlikely to acquire popular acceptance.

Sloping hillside lots can provide very effective building sites for in-earth structures and offer an attractive alternative in a country where we are consuming prime agricultural land for tract housing at an alarming rate. With proper planning and design, sites too steep for cultivation can lend themselves admirably to homes built into the earth.

Sunken courtyard houses around an atrium, like John Barnard's much-publicized "Ecology House" in Massachusetts, offer a delightful answer for areas where the visual scene topside is less attractive or where high densities are desired. One can envision a subdivision of these (if one must have such subdivisions

at all on flat land) where little is visible on the surface except roadways, paths and access areas. Such a scheme would provide more room for gardens and trees, room for children to play and a very controlled visual environment both on the surface and from inside each dwelling. Patio privacy too would be maximized in such an approach without miles of privacy fencing so typical of our conventional postage stamp surface lot alternative.

Berming with earth up to windowsill levels or over the roof offers thermal benefits in situations where the watertable or bedrock is too near the surface. And finally, similar effects can be achieved in an existing knoll or under the crest of a hill with greatly reduced weather exposure and far less jarring visual impact.

As I indicated earlier, I view earth-sheltering alone as only one part of designing a more environmentally responsive and potentially self-sufficient home. With proper planning such a design might ultimately incorporate many or all of the following: shelter and insulation, earth-cooled ventilation, greenhouse space for solar heat collection and extended growing season, an independent water source such as a well or rainwater collection and storage, secured storage space for items of value, multiple exits and storm protection, fireproof construction and furnishings, passive heat storage for solar or woodburning sources, windpower, maximal natural lighting, increased planted space and rainwater run-off management. In other words, if you are going to venture as far as earth-sheltering, don't just push some dirt on a conventional house. Carry innovation a step or two further. Underground homes of twenty years ago weren't much improvement over their upstairs neighbors except in reducing heat loss. Today we can build more truly responsive and healthful environments that better meet a host of needs and which, with small passive solar inputs, can maintain comfortable temperatures through the worst northern

winters on little more than a cord of wood. So why not do so? The federal government has written off the northwest as inappropriate to solar housing, but I believe this is because they have conceived the possibilities too narrowly and without proper consideration to the whole thermal equation. If more effort is devoted to reducing heat losses, the demand for solar input can be reduced by as much as eighty percent or more and any further shortfall can be made up with wood -- a plentiful and renewable resource in our part of the country. To ignore the benefits of earth-sheltering in designing an energy-efficient home for our region is like trying to pour in water fast enough to fill a sieve without considering the possibility of first plugging the holes!

In dealing with any architectural problem, models are a valuable tool, especially if space relations or design are complex. Today I've brought two models representing student work from WSU. The first is a school utilizing skylighting and deeper light wells to provide natural illumination on several levels. As you can see, such a design leaves most of the site free to provide recreational space on the surface, hence a smaller site is required than for comparable classroom space on the surface. Also, such a part-topped school is less out of scale with surrounding residential usages than a several story brick monster on the surface. (Editor's note: Terraset School in Reston, Virginia, incorporates such features , as will the school at Heart Butte, Montana.)

The second model is of an earth-bermed farm for the Palouse country; I understand this farm is presently under construction. Here the berm forms reflect the rolling hills typical of the area and provide both thermal and visual sheltering for a variety of farm buildings and equipment storage areas which might otherwise add one more eyesore along a rural highway.

Much of the current professional interest in earth-sheltering can be traced back to a 1963 Malcolm Wells article in PROGRESSIVE ARCHITECTURE which featured

his "Random House," an organic, free-flowing structure shown here. This design is clearly suited to its site, conceived to relate to it and pick up on its natural forms, to be a delight to experience from without and within while at the same time demonstrating environmental sensitivity and relative energy efficiency. Though never built, it paved the way for others which demonstrated in more tangible form that underground design need not be limited to boxes with windows on one side. It introduced the ideas of fun and adventure in terratectural design.

This is one of Mr. Wells' more recent projects called "Raven Rocks" which has taken more tangible form. A relatively self-sufficient project exemplifying many of the considerations I outlined earlier, it collects its own rainwater, generates its own electricity by funneling wind through the fan-equipped venturi on the roof, depends heavily on passive solar for warmth and baffles for heat management and conservation, includes greenhouses and office spaces so one can live there for an extended period of time without needing to travel elsewhere for supplies or to work and even uses ecologically sound composting toilets to deal with and recycle waste. All in all, I consider it a model example of soundly planned house on a hillside site too steep for agricultural utility.

This next slide shows Malcolm's first underground architectural office. It's a bit difficult for an architect to operate out of a surface crackerbox and convince his clients to build underground, so Mr. Wells located on this plundered parcel of land next to the freeway, which was no longer needed to stockpile gravel, and set about converting it into a livable habitat for humans and a host of other living things. The building is a very successful design even though it failed to take into account some of the most recent innovations like external insulation and barriers to thermal bleed. It not only proves

a quite pleasant demonstration of earth-sheltering for habitable spaces but recreates a natural enough rooftop environment to sport a surprisingly varied wildlife population as well.

Mentioning the outdated insulation approach of Malcolm Wells' office brings up a point worth considering. We are still in the early learning phase of this new (or rediscovered) direction in building. What we build today will likely be viewed as primitive compared to state-of-the-art by 1985. It is a field just opening up and much of the adventure and innovation lies ahead. Also, a great deal of pioneering still needs to be done in sharing what we already know and promoting its applications in what might seem obvious areas. For example, we clutter our landscape each year with thousands of essential but generally ugly buildings which don't need to be fully above grade to perform their necessary functions. Who says that a highway maintenance building, a warehouse or a pumping station must be on the surface? The same could be asked regarding any windowless structure. What about our so-called "industrial parks"? If those aspects of their operation other than management offices and access were buried, would they not be more economical to operate and maintain? And certainly such an approach would better play up the "park" concept while disarming the "industrial" aspect.

There is plenty of room in this new field of construction for any who are prepared to meet its challenges and the psychic rewards are great. I'm pleased to see so many of you giving it serious consideration. To clarify my own position, I rarely function in the conventional broadspan architectural capacity on any particular project. I'm only there to add the insight born of experience in the special demands of going underground in many cases. I prefer to serve as consultant to a regular architectural office, letting it handle as much of the task as possible, or provide preliminary suggestions and encouragement and

the rest of the job is handled by a local firm. Or I go over drawings at various stages, making constructive suggestions or congratulating the client for finding a designer so skilled in this specialized approach. Since the time I can devote to this and still pursue my writing and publishing is limited, I only accept a small number of projects which I fully oversee and try to limit those to special ones of particular challenge. When my schedule allows, I also enjoy working with owner/builder/designers since they so often prove the most willing to venture into such new and unchartered waters. But enough about me; let's take a look at what some of the other earth-house pioneers are doing around the country.

This dramatic structure straddling one of Florida's coastal sand dunes is architect William Morgan's own home. Like too much of our building today it exemplifies the dominance of man over nature. Admittedly it is exciting and draws your attention but seems rather dominating on its site, like a well-designed billboard. When Mr. Morgan decided to construct a duplex next door, he took a very different tack. It passes through the dune from street to beach, maintaining the natural contures of the site and is certainly much less jarring than its neighbor. It is constructed with a curved structural shell and provides a sheltered patio area and views of the water from it's oval sea oriented "eyes." The sunken entrance at the street side is equally unimposing, even if the automobile parked in the open isn't. I don't know what we do about our cars. Whenever budget allows, I include subsurface garaging but that can be expensive.

This next one is the "Ecology House" I mentioned earlier. Although it has been around for some time and has evolved a bit, the basic concept is still sound. It was living proof of the potential economies of earth-sheltered construction both initially and in operating costs. It has been an ongoing

inspiration to others contemplating digging in. In designing this sort of sunken courtyard house myself, I've made several changes that I feel greatly improve the aesthetics and utility of the basic concept. One is to provide access away from the central courtyard (at two places for safety reasons), so the light court itself can be glazed over for greater weather moderation. The other is to replace the industrial looking safety railings with protective landscaping concealing chain link fence. It's nicer to pick raspberries or grapes off that barrier than let a jarring handrail spoil an otherwise natural effect.

Here's a picture of the light spilling in through the windows. Compared to surface structures, more glass area can be used in an undergrounder because glazed areas tend to be more protected from air than on the surface and heat losses through non-glazed earth covered walls are so greatly reduced. You can also see in this picture that a high efficiency fireplace is used to provide supplemental heat in the Ecology House.

This is a slide of one of Palo Soleri's early subsurface silt-formed desert structures. Although he claims to have no interest in earth-sheltered housing, he's provided us much inspiration through this early work.

David Wright has designed a series of structures combining earthmassing and passive solar heating. The first were in New Mexico but this one is his own recently built home at Sea Ranch on the Northern California coast. It receives the majority of its heat by passive solar collection and storage with a small wood stove on standby for extended gloomy periods.

Taking a much more mild approach, this Visitors' Information Center in Jackson, Wyoming, is above ground but with six inches of sod and native plant materials on its roof. The architect told me this was done strictly for aesthetic reasons, but that the energy savings and longer roof life have been side

benefits. The sod came from the parking area in front of the building and blends in nicely with the elk refuge area and hills behind. At a time when most information centers are ugly little "A-frames" or toadstool-like geodesic domes, this one is a delightful change of pace.

Speaking of parking lots, here's an underground one at a resort in Colorado. If you want to set off a nicely designed building on a beautiful site, placing a sea of cars in front is going at it the wrong way. If you doubt that, take a hard look at the acres of painted metal and chrome that surround the lodges in Yellowstone. Just because our senses have been dulled by so much of the parking lot syndrome doesn't make it any less ugly.

This next is a series on a circular, earth-sheltered home brought to completion by David Scott in Pullman, Washington. This design originally received harsh criticism from many in the community. I'm not sure whether they were more offended by the fact it was underground or its round plan. In a small town not noted for its architectural awareness, the two concepts in combination horrified people. After about five years they began to accept and judge it on its merits. Part of the problem originally was due to gossip about some of its technical difficulties. At the time it was started the original designer was unable to obtain sufficient funding to complete it and so had to let it go. At that time, about ten years ago, it was still mistakenly believed that earth alone would provide sufficient insulation. When the exterior proved a continuing source of dripping condensation, it was necessary to go back and excavate to place foam insulation part way down and wash the lower part of the curving exterior wall with ventilation air.

Also the skylights, which were a major feature of the design, leaked a bit. Those of you involved with building know such a problem is not unique to subsurface structures by any means, but the uninformed tried to tie the two together.

A lesson might be drawn from this. If you are into doing an underground house to showcase the idea, be most careful with its design since there will be those who, in their unconscious efforts to resist any sort of change, will be eager to condemn the basic concept due to one or two minor and unrelated functional problems. So do your homework well before breaking ground. Otherwise, you may make it harder or impossible for others in the area to gain financing or other acceptance for their earth-sheltered designs because yours didn't work. For a number of years the Pullman house sat unfinished since local bankers wouldn't touch it. Finally David Scott was able to borrow out of Spokane on his personal reputation to do the job up right. The same could happen elsewhere.

The Pullman Round House is now completed and both delightful and functional. Its curving two story exterior wall was poured against rough sawn wood and is flooded with light from 28 semicircular skylights. The upper floor public areas are reached by a bridge through a round opening in the perimeter wall and surround a kitchen totally covered with a central skylight. Stairs opposite the entrance lead to the lower floors' bedrooms and baths which look onto the perimeter hall through sliding glass doors which admit light but bar distracting sounds. A two-story glass element looks out from living room and master bedroom to the WSU across the valley.

I'd like to wrap this up with a few shots of a hilltop site northwest of Spokane overlooking the city for which its owner is designing a through-the-hill underground home under my guidance. It seems that people too often fall in love with a pastoral site, deciding it's the kind of place they'd like to live, and then proceed to destroy the character of that site by putting a conventional urban tract-type house and accoutrements on it. I'm pleased to see the commitment of the owner to this six acre parcel to maintaining its pristine character. That's what makes it all worth while.

I hope I've been able to convey to you today a feeling of some of the possibilities of earth-sheltering, but remember, this is only intended to give you a place to start. For goodness sake, don't just go out and duplicate or replicate what you have seen here. Use this as a springboard and try to make each design a little better than the last, as I too will continue to do. Thank you.

PANEL DISCUSSION

JIM KEMBEL, Administrator, Building Codes Division, Department of Administration:

As usual building codes do muddy things up a little bit. There are sections of the building codes that allow building inspectors to grant approval for alternate materials and methods of construction. I think most of the problems that are encountered could be handled in that manner. But just briefly to give you some idea of what we are faced with: first of all sleeping rooms in a residence are required to have exit windows in case of fire; the ventilation requirements of a house must be met by natural or by mechanical means; required to have natural lighting, of course, by windows. These sorts of things could be handled with skylights or the mechanical system. The bathroom areas, of course, and the laundry room areas again require ventilation. Some means have to be provided to keep the water from penetrating the surface of the interior walls, One of the things that has become a large problem to the building industry over the last few years is the problem of insulating buildings. This prompted the use of foam plastics, and now we do have special requirements in the codes covering foam plastics. The material can be used but certain precautions must be taken. One of the big areas that concerns me -- perhaps because of my engineering background -- are the structural problems. Underground housing is not going to be that easy to build for the typical homeowner. I think that caution has to be used. There are tremendous amounts of loads put on those structures from the earth, water saturating the earth, snow, trees, vegetation, maybe vehicle instrusion for some reason other than purposely -- you might have an accident and end up with a car on the roof, and earthquakes. Those types of things I think individuals should seek professional help on. The code does allow for the building official to require some plans to be prepared by professional individuals and this particular area he might just require that be done, depending, of

course, on the complexity of the design.

Another area that gets rather interesting -- and we can spend a lot of time on it -- is back-filling and excavations. You just don't go out and dig a hole. You owe something to your neighbors and the code does address that. For instance, excavations 12 feet or less require that you notify your neighbor ten days before you make the excavation, so that he is aware of what you are doing. Then you must allow him access to your site to do any work necessary to protect his own property. You must at the time you are doing the excavating protect your property from caving or undermining the neighbor's footings. When you get to the point of 12 feet or more, then the person next door must be notified. He has to provide the foundation down to the point 12 feet below grade but then you are required to furnish the foundation to him from the 12 foot point on down.

Soils are another thing that have to be studied. Expansive soils can be a real problem; frost heave as was mentioned earlier can be a problem. But the types of soils can be a real problem to the design so you want to be sure of ground water levels. And as might be figured soil is not listed as one of the approved roofing materials so that it is an alternate which must be approved.

One that I haven't spent much time thinking about is skylights. Skylights will be necessary to get the light in the ground but they must also be protected, not only from animal intrustion but human -- kids --whatever. If the skylight used is completely flat the only way you could use glass is if it is half inch thick, which gets very costly. But some means of guard rails must be put around the skylights, or perhaps planting could be used. The other things are plumbing vents, mechanical vents for gas furnaces or wood stoves; somehow those must be provided and protected. The other thing that could be a problem is lift stations for the sewage systems; those can be a real problem and would have to be ade-

quately designed.

We can get into actual numbers or figures if you care to do that this afternoon.

JERRY HAMLIN, Local Contractor in Helena:

I was happy to hear Paul say to confine our comments to ten minutes as I think I could say mine in about ten seconds because they have all been covered. The future energy outlook is indeed serious, especially in the gas and oil reserve area. Estimates of these supplies running out range from 20 to 40 years with some such as coal going on further. I view earth sheltered housing as a possible method to reduce an ever increasing demand for our dwindling gas, oil and coal reserves.

Even though earth sheltered housing is not an entirely new concept, the fact still remains that it is unique and therefore is received with the usual skepticism associated with new ideas. From a contractor's viewpoint, (and I'm not an expert at it as I have not been associated with earth-sheltered houses) I can foresee some problems associated with building these homes, problems that can be worked out but nevertheless problems unique to this type of building. My major areas of concern: obtaining the acceptable building site that would lend itself to an earth sheltered home; you would have to check out the soil characteristics, water table, proper exposure, whether it's in a sloping lot or flat lot. Designing the dwelling with proper lighting techniques would also concern the in-house lighting as well as the natural lighting and the window placement, the air infiltration, that type of thing. Mr. Kembel also mentioned the additional ventilation requirements. It may not be too much of a problem with the conventional forced air heating system because the ventilation could be hooked into the system fairly easily. One other item: I noticed they had some double floor models but I am afraid it would get fairly expensive when

you start putting two floor levels underground, and I think that would necessitate building a little bit larger, more expansive home because of no basement or garage unless it were attached. We have to look at the total picture -- from design to the marketing aspect. We have to do away with the mole syndrome. I think that could be done with the proper advertising and proper setting up.

Anything new is bound to have some problems but these problems do not seem to be insurmountable, yet they do deserve thought and discussion. Underground buildings will cost slightly more and I think this is in contrast to something that was said earlier. I feel that because of the structure problems related to it the construction of underground housing would be more expensive and then you always have ventilation requirements, open courtyards, etc. I have seen estimates all the way from 10 to 20 percent higher but I can't justify those because I have not built two houses, one underground and one next to it. In the years to come the additional costs associated with building underground housing may well be offset by the fuel savings that will come along with that type of design. I think the higher fuel costs rise, the more feasible will be this type of design. In a time of depleting resources, I think we have the obligation to explore this kind of housing.

A. ALAN KIND, Appraiser with Jack Moore Associates:

Many appraiser problems associated with earth sheltered housing have been touched on. As with an innovative design or product, problems are certain to surface with respect to acceptance by the potential buyers of the product. Something as major as innovative shelter has an additional problem in that most of the people in this room, myself included, cannot just go out and buy it. They have to obtain financing. I would like to define a few problems as they pertain

to evaluation and marketability of these structures and the potential buyers ability to obtain financing to make the purchase.

The basic concept of earth sheltered housing has been very well covered. Two areas that I thought would be of interest in the marketability sense are the energy efficient construction in the face of the rapidly rising fossil fuel bills, and the better use of the earth's surface. You could have a larger yard area with a lower cost lot.

Looking over the group I am sure there are many who are quite familiar with the appraisal process, so due to lack of time I will just touch on those areas of the appraisal process which will be different when considering an earth sheltered house. An obvious problem when trying to integrate an earth sheltered house with more conventional housing is its compatibility with the neighborhood, which is one of the items that is covered by the neighborhood analysis on appraisal. There are two things to consider here: compatibility in the sense that taller conventional surrounding structures may interfere with the passive solar gain of the earth sheltered house; also, the compatibility in an aesthetic sense. Quite contrary to what Mr. Stephens has said, people who are used to a conventional arrangement of boxes sitting on top of the ground would very likely be offended at someone putting an earth sheltered house right in their midst. It is there that one of the primary appraisal problems is found.

As far as the site itself is concerned, I just took a quick look at the zoning ordinance to see if something in it said that the living area has to be above grade. In that quick look I didn't find anything, so I don't feel there should be any great problems, other than in the aesthetic sense we talked about earlier. The use is basically the same; whether above or below ground it would still be a single family residence. What would require more consideration is the soil type, ground water conditions, drainage, topography in general and

the relation to the surrounding area. The improvements themselves don't really fit the form that we're used to as appraisers and that most of us here in this area commonly use.

In appraisals we have different approaches to arrive at a final figure. The Cost Approach might be the best way to arrive at a value, as there is no market value to go from yet. Ordinarily we rely on the market value heavily and if you don't have any you feel you are on pretty shaky ground. A possible solution is using the same basis as we are doing for solar -- which is placing an arbitrary rate on the structure and not loaning beyond that amount. The bank (and they must look at this as a piece of property they may someday own) will take what the appraiser says the house is worth and then give 10 percent above that amount. An arbitrary allotment system could be devised based on square footage or number of rooms and from there get a maximum that you would loan in that area. As with solar, we could compare what the energy costs would be to what a regular house would use and then take that as a basis for evaluation. Since earth sheltered is likely to offer a bargain in utility rates, as time goes on this type of design will command a greater portion of the buying market and there will be a lot more construction and we will have market data to build on. At this point, however, the financial outlook for loaning on earth sheltered designs is not very good.

(In the afternoon, the workshop broke into informal discussion sessions, at which the participants were able to question the experts and each other. The sessions are identified in the transcript by the expert present, and the location in the library of the meeting.)

RAY STERLING: FIRST SESSION — Upstairs

QUESTION: How do you deal with the marketing problem?

STERLING: There obviously is not widespread experience with marketing. However, consider that two years ago, with the exception of the ones that Don and others were building away secretly, the major earth sheltered houses in the country were probably the ones that are listed in Earth Sheltered Housing Design, maybe twenty in there and probably a few dozen more. Well, this year there are probably three or four times that number being built in Minnesota alone and I think the same is true of most of the states around. The number of earth sheltered houses has gone from just a scattering to several hundred, probably into the thousands by sometime next year. And when you get that number of houses being built, it is not going to be too long before there will be some kind of a market test.

Once you get into building developments you see some big benefits. Even though they are individual houses, you can do excavation more cheaply because you have the equipment on site for a number of houses, not just for one. You can build common walls if you like. Even if the houses are spaced out above ground, you can have common walls underground. You can use prefabricated elements of exactly the same design repeated over a number of houses. With only a few earth sheltered houses being built, we haven't found all the cost cutting corners yet, as we have found with conventional houses over a period of about fifty years. Costs are going to come down and also this problem of the

of the house not matching the neighborhood will disappear. When you build a development of earth sheltered houses, you get a very pleasant neighborhood because nothing is out of character with anything else. I think, although the picture looks quite gloomy at the present for financing, people are getting financing. The individual banks are willing to make a loan because they think the person's design is sound or maybe because he isn't asking them for too much money. The down payment is very high in some cases. People may know somebody at the bank and the loan is really based on the strength of the banker's personal knowledge that the fellow isn't going to renege on the loan. We have had discussions with Northwestern National Bank, First National Bank of Minneapolis, some of the really big banks there, and at the top level of the banks they are very interested. I think they would like to get some nice projects that they know won't fail, well designed, and fund them and get a little public relations out of it for supporting energy conservation.

We are doing a study for HUD on code and financing of the houses. I don't think that we will turn up any surprises. What Alan said this morning is pretty much the response we expect to get from banks. But at least it will be documented. Then if HUD decides that they do want to provide funding for earth sheltered housing, I think we will be in the same stage that mobile home housing was in about 1960. You couldn't get a loan on a mobile home for exactly the same reasons. Then the government decided that mobile homes were a valuable thing for low-cost housing, so they set up government programs specifically to underwrite loans on mobile homes. Once the banks had that government underwriting, their risk from making a loan on an underground house would be removed. Then they are happy as pie to make loans. Once you take away the risk, they don't mind loaning money on anything.

MIKE ELDER, American Federal Savings and Loan: Even with government backing,

you still have the hurdle of what truly is market value. Until you get some kind of track record, you will always have a question mark in a financial institutions as to whether or not, if they end up with that thing in their laps, they can turn around and get rid of it without taking a loss. Of course, there are different ways that you can protect yourself. You can make a loan on a project whereby maybe you're fifty percent exposed. If you feel that cost of land is half that exposure, you can remove the building or bury it and, therefore, get some of your money back out. We approach it from the beginning in terms of what could happen in the worst circumstances. We have to be concerned with what the government will say if we lose our lenders' money. The average individual will not be able to afford this kind of financing immediately.

I was talking with Mr. Savage over lunch about his experiences in trying to build his home. He has the backing of government now and the experimental housing program - the 233 - and because of that he has a financial institution willing to give him the final take-out loan. Now he can't get enough money for the construction in the interim. It is back to the old question of what type of problems are going to be coming up in the construction phase of it that may delay or jeopardize that final commitment coming, since he only has 120 days to get it built once he gets on the project. There are a lot of questions, among them marketability and education of the financial people, so they'll know who is reputable in the business.

QUESTION: How does this apply to rural housing? Farm/ranch housing in particular, where it is established that there won't be a turnover in ownership unless the entire farm is sold.

ELDER: I am not able to speak technically to that because most of the Savings and Loans are not into the farm business per se; most of your smaller town banks

are. I would venture that if the government would back it up, you would have more of a likelihood of getting that kind of financing. But certainly anytime that you protect a loan with a longer duration and dependability of payments you are going to be that much better off. Like I say, on the average for a conventional house in town or the fringe of town, people aren't keeping homes eight years before they move.

QUESTION: Has the state of Minnesota looked into guaranteeing loans?

STERLING: Not at present. I think the state is waiting on the results of the demonstration program: the number of people who seek to buy the houses on demonstration, the public acceptance of them, and also the results of the energy use monitoring. The energy agency is considering putting together what they might call an "Underground Legislative Act". The main purpose of this would be to tidy up some of the legalities concerning underground construction, not so much regarding homes, but in mine space development with two levels of ownership on the same site. Taxation laws don't provide for a double taxation of that site with two different owners, on the surface and underground. Incorporated in that may be some further programs but at this time I don't believe there is anything under consideration by the state as far as underwriting.

QUESTION: It seems that Minnesota has its track record. How far along are they in development and construction?

STERLING: Some are under construction already. The others will be under construction in the next month or two. I'm afraid it is going to be a very limited track record as far as institutions like the banks are concerned but it will be at least a start and an indication.

QUESTION: What is the price range of the houses that are being built in Minnesota?

STERLING: These were aimed more to be demonstration than low-cost houses. There was a stipulation that the ones built by the building contractors should sell for less than $75,000 -- I think housing construction costs probably are more expensive in Minnesota than here -- and the houses probably are in the range of 1800 to 2000 square feet. So we're figuring a rough cost of about $40 a square foot, which is pretty close to the cost for ordinary houses built on an individual basis.

I have some questions on the code that I would like to put to Jim Kembel here and maybe it will bring up some other questions as well. If we just ran through the provisions again: one is the window for exit, another is windows for natural light requirements, and another one is the ventilation. My feeling is that the ventilation provisions in the uniform building code are flexible enough. You can provide openings 1/20 of the floor area, or you can provide mechanical ventilation of a certain amount, so that you have your choice and it seems to be quite an equitable arrangement. On natural lighting, if people want it, fine, but I don't think they should be forced to put it in if they don't want it. Another, more detailed point on natural lighting is that it has to be a direct exterior window, at least according to the codes. So in other words, if you have a sunroom on the outside of a house, those windows opening into the sunroom from say the living room, would actually need a variance to be counted as providing the natural light, even though they received natural light through a greenhouse.

KEMBEL: I think the only way around this problem presently, other than variance, is having 50 percent of the room wall open to the area that is receiving light, and the room you're trying to light, with a minimum of 1/10, I believe it is, of floor area. Then you could actually treat the two as one room for light purposes and use that light.

STERLING: The question I have for you, as somebody who deals with building codes, concerns the abolition of minimum glazing requirements. Windows are not a bad thing as far as energy is concerned but I think people are going to be eliminating them anyway. On something like a bedroom, a lot of people have said to me "I don't want any natural light. All I use my bedroom for is sleeping. I would rather another room have natural light." You get into the exit requirements there. Except for the exit requirement, is there a very good reason why you shouldn't be able to exclude certain areas of the house that are habitable rooms from the natural lighting requirement?

KEMBEL: The only reason I could think of is aesthetics.

STERLING: Does the building code really see its function as regulating aesthetics?

KEMBEL: I think so, to some degree. I have not had the opportunity to question that requirement. We can find out for you the intent of each code as it is recorded down at the headquarters where the drafting was approved.

QUESTION: Is the uniform building code binding to every residence in the state?

KEMBEL: At the state level we set the model codes to be used by the local jurisdiction and they have the option of adopting it or not. If they do not adopt it then we enforce the codes in those areas. The problem at the state level is that given the way the laws are written we cannot enforce against single family dwellings. We do cover commercial and apartment houses. So if the city does not adopt the code locally we probably would not cover the single family dwellings.

QUESTION: Is a copy of the code available in most public libraries?

KEMBEL: I would think there should be. We have them for sale but they are expensive.

COMMENT: I'm having no problems with the codes as they are. If underground architecture proves itself to be energy efficient, then the codes will find

themselves changed to encourage it. The problem that we're working on up in Libby is "How do we get costs down so people will buy them?" and "Once we encourage them to buy underground housing, how do we get them to be less consumptive in their daily lives?" I see the possibility of underground architecture eventually getting into two car garages and garbage disposals, and a lot of the energy intensive things you have in regular above ground houses. So is that really an alternative?

STERLING: I think you are right. One way of conserving energy is to just cut down the amount of space in a house and you can also cut down a lot of other things. There will be a group of people who really feel strongly about conservation and want to shrink their dependence and return to a more natural way of living. But over 50 percent of the population doesn't even believe that there is an energy problem. The way I feel about that is there will be a lot of big houses built underground, but if the garbage disposal doesn't work you can do without it. Three car garage -- you may not be using it for cars but you can use it for something else. The house will still be functional, even in a severe energy crisis. If you build a smaller conventional house you may initially achieve much the same energy conservation, but you don't have the same independence from the overall energy problem that you do in a larger earth sheltered house. The question is what can you realistically expect the general public to do in this situation. Eventually epople will do whatever they have to do because they will be forced into it. The only way of easing that transition is to conserve as much energy and transfer as many people to a more conserving way of living before that time comes. I think the only way of converting enough people to make a significant saving is to make it attractive enough that more people will want to do it.

QUESTION: But that includes the question of price.

STERLING: I think they can be built at a very competitive price. Now earth sheltered housing can also cost more, but I think the cost will come down. People who are building them on a regular basis, who essentially have three or four models that they are building different places, say their costs are very competitive with, if not lower, than the conventional houses.

COMMENT: One of the most important things is the circle graph slide you had depicting total energy use. Seventy percent of the total home energy use was consumed by space heating and cooling, a very good sales point for earth sheltered homes because that is an area where you can cut out a lot of that pie.

STERLING: If you present someone with the alternative of saving a certain percentage of energy by either cutting the size of his house down, way down, putting a lot more insulation in and building a surface house or having a little more space in an underground house, then I think that is an attractive feature.

COMMENT: Particularly projected over the life cycle of the home.

STERLING: When you look at life cycle costing, you almost feel that you should ignore the initial cost of the building. A Dr. McWilliams from the University of Texas presented a paper about an earth sheltered house which he very conservatively estimated at $100,000 to build compared to an $80,000 house of equivalent size and everything else on a tract house development. He ran it out over a 30 year life cycle and picked some quite conservative energy escalating costs of heating and maintenance figures and return on extra money that you invested. For the first 10 years or so you paid a little more because of the mortgage payments on the earth sheltered house because it cost you more originally. But then I should also mention that house had 8 feet of earth on the roof. That is why it cost $20,000 more. But it required no air conditioning, no heating; down there the soil temperature is about the temperature you would want anyway. But after that period, because of the exponential growth of the energy costs --

the 6 percent per year is 6 percent on the inflated price before, so it goes up in an exponential curve -- your savings grow larger and larger until at the end of 30 years you are about a half million dollars better off to have the earth sheltered house. That is because if you inflate energy and those things at the rate we are going right now we'll be paying nearly $20,000 a year for our energy bills 25 to 30 years from now. That may seem crazy right now but houses used to cost less than $10,000, now they cost $80,000.

QUESTION: That brings me to another question that I might direct to the gentlemen from the Savings and Loan. Because of the durability of these structures, is there a likelihood that the mortgage repayment time could be stretched out even beyond 30 years?

ELDER: This would be a governmental regulation change since they limit us now to a maximum of 30 years. Unfortunately, we run into a problem in respect that interest rates right now in Helena are 10 percent to 10¼ percent. You shove it out 40 years, it gets a little hard to pick up a payment that is going to pay that back.

STERLING: What you are saying is that going from 30 to 40 years does not save you that much in the payment because you are paying almost all interest to start off.

ELDER: In the long run that is true. It might increase your payment by a few dollars a month but overall costs are so inflationary. This is the problem we are running into now with the cost of housing as it is even in conventional building. It's getting to the point that the size of the loan people are after is such that they can't afford the payments. So you try different things -- variable rates, different things like this -- and it still does not work out right. There are other problems when you start talking about realizing costs back from energy savings in ten years. Here again, that is not really a sales

point to most people, especially in such a mobile society as we have. They say, well I haven't been in a house more than 8 years; a lot of them say not even 5 years. So where is the savings for me; I'm paying all the front end, and somebody else will get the benefit from it.

STERLING: The one aspect of McWilliams' analysis that I didn't think was quite accurate is that the earth sheltered house would maintain its value with respect to the other house, because it had a lower potential energy use. Assume that it will retain its value, and that the two go up in price, then whatever time you sell the earth sheltered house, you still come out better off than with the conventional one. The dubious point is that, once you built it, does it still remain a $100,000 house or does it suddenly become an $80,000 house. And that is where the market test comes in again.

KIND: FHA does consider energy costs. I hate to say we don't really consider that unless we know that it had been built at a time when they didn't put insulation in the walls and ceiling and then we may consider that as a detriment. But even at that it is just one of the minor issues to look at. Yet, it is a thing that the institutions are growing more and more aware of.

COMMENT: In New England some of the energy bills are now more than the mortgage payments.

STERLING: One thing I would like to come back to. That analysis was done for Texas and with a structure with a much higher initial cost. If you can build the structure for the same amount or less than a conventional house, then your savings start right away. So from that respect I think his analysis, except for the one point I mentioned, was in every respect extremely conservative.

COMMENT: It may be a good idea for the Helena Valley Home Builders Association -- if some such group exists -- to tie together with the bankers and maybe some other financial institutions in the community to develop a couple of prototype

homes in the valley, announcing at the time that this is an energy conserving alternative. The banks certainly couldn't lose anything with advertisement like that. The public would gain an incredible amount of knowledge and the builders would gain an incredible amount of experience. And all three, including the public, would support it.

STERLING: That is essentially what the program is in Minnesota. It basically came about because one of the state senators heard Dr. Bligh and Dr. Fairhurst speak one time on underground construction. Dr. Bligh is a marvelous speaker; he just really sold the Senator. Also, they got together at various meetings. The Senator was in charge of housing appropriations, which is about a 40 million dollar program for low-income housing in the state. He figured if this has this much potential, we ought to do something about it. He put in this half million dollar appropriation plus another half million for other forms of alternative housing right in the appropriation and he said "If you don't keep this in -- no housing bill." He put it in there virtually single-handedly, over a lot of opposition and resistance. Now, the same people that were opposing him think it is a tremendous program. It's being administered by the Minnesota Housing Finance Agency. We are doing the monitoring. The Housing Finance Agency has the tie-ins with the big banks because they do a lot of business with them. The banks really would like to get in with some well controlled projects like this because there is a lot of potential PR in it for them, plus they are not putting their neck out by not knowing the people who are involved. In other words, they are probably getting the very best of what is being done in Minnesota, so their chances for loss are practically negligible and their chances for good publicity and also gaining some experience of what to look for is right there.

QUESTION: What kind of response has your program received?

STERLING: As it got out that we were doing the earth sheltered housing design

project, the number of letters coming in started to grow. We had 5,000 by the time we finished at the end of the year. We had 4,000 copies of this book printed. It came out about the middle of March and we sold out last one last month and we are getting another 6,000 as an interim measure. We are not sure what to do with the book on a long-term basis. We get about 30-50 phone calls a day, mostly from in state but also from all around the country. People want information. It has got to the point that I just stand on a bus or go into a store and hear people talking about the possibility of underground housing construction. I think the people are way ahead of the government and other institutions that are involved. And I don't think that the federal government in particular realizes that yet.

QUESTION: Have you done much with solar?

STERLING: You know solar has a romantic appeal but they haven't been able to get the initial high cost down. Active solar systems are very mechanically oriented. There are many things that can go wrong with them all the time. And people are starting to think, "Well, solar isn't quite economic yet." "It may be economic later on but what can I do right now." I think this is an alternative that can be done right now. I think this is an alternative that can be economic right now. But there is no reason why you can't build an underground house right now and leave provisions for solar to be added later.

QUESTION: What does a yard of concrete cost in Minneapolis-St. Paul? What figures did you use in your estimates?

STERLING: I really couldn't tell you offhand. We had the estimate done by a local small contractor that does housing and small commercial buildings.

COMMENT: $30 a yard in Circle. COMMENT: $38.50 in Helena. COMMENT: $40 in Billings.

STERLING: I would like to come back to some of the code questions. Some of

the finer points of the code do affect quite a lot what you can design and how. I think you can very easily design a house that meets all the uniform building provisions, but let's get back to the question of having an exterior lighting coming through on a greenhouse. Am I right in saying that is not permitted under the letter of the code right now?

KEMBEL: If it is 50 percent open to it.

STERLING: That 50 percent open brings up another question. We wondered if you put a bedroom to the back and you left the wall between that and the room to the front 50 percent open, but then have a removable partition or curtain across that space, would it qualify? That is where you get into those interpretations. In Minnesota the building code people thought that it had to be really open to be classed as open -- certainly no partition and probably no curtain.

KEMBEL: I don't think the code even addresses that; it just says open. It would be interesting if you asked building officials who said you can't have curtains between a bedroom and living area, but who allow curtains and shutters on windows. To me, that's one and the same.

QUESTION: When you say the locality has to adopt the code, are you talking about a municipality or a county or what?

KEMBEL: Right, either one.

COMMENT: If a county adopts a municipal building code, it probably pertains to all the towns in the county.

KEMBEL: Yes, it could. If a city is doing something within that county, the city would probably have priority. The county has a problem in that recently our attorney ruled that the county can only cover the same as what the state covers and not single family dwellings. That is going to be an issue of this session of the legislature.

QUESTION: What is in the wind right now?

KEMBEL: The counties that I have talked to want to cover them; they are upset that they couldn't. You must realize these are areas in which there is a tremendous amount of building going on. They are having a lot of problems with roofs blowing off, etc.

COMMENT: Here is a barrier I can see: a requirement that there is to be so many square feet above grade.

KEMBEL: That is getting into zoning. The question has been raised several times as to whether or not the zoning ordinances can set the square footage you can have in your home. And I have not heard lately how that has been holding up in court.

STERLING: When we looked at zoning we polled a rather limited number because of time limitations. In one case we found a basement ordinance that just said "No basement houses." Now how you interpret an earth sheltered house is very much up to the local person. But the ordinance wasn't designed to prevent an earth sheltered house; it was designed to prevent a basement which would never be finished. The zoning official felt if that problem came up, they would go to the local council and reword the ordinance so it didn't prevent a properly designed earth sheltered house. Another group that I know is building in Burnsville, a suburb of Minneapolis, where they had a minimum square footage above ground provision. Their house is below ground on the backside but it is above ground on the frontside, so it is a moot point as to whether it is an above ground or below ground house. But it was approved without any change in the wording. The official just felt it was proper living space and that there was the minimum square footage on the main level. He looked upon the earth as more insulation around the house than anything else.

KEMBEL: The major worry about basements is they often do not have windows which are needed for exiting purposes. The windows must be within 44 inches of the

floor. Very rarely do you find a basement that meets that. I think in Helena what is happening is that they are actually enforcing that finally, but that has been in the code for many years. I read some documentation the other day where an alternate was considered: a ladder and a skylight. Your jurisdiction would have to rule on that. The building inspector can rule on an alternate, or he can send it to the Board of Appeals for a ruling. If you don't like the decision of the inspector you can take the alternate to the local board yourself. So you have that out.

STERLING: How long does it take to go through this process?

KEMBEL: Depends on the local rules but normally I would say a week to two weeks.

STERLING: On the exit provisions the uniform building code doesn't allow two alternate exits through the house. The HUD Minimum Property Standards do. How do you feel about that?

KEMBEL: I think it would be a viable alternative. If it is a protected corridor that has self closing doors. Smoke detectors alone would not do as they are already required.

STERLING: I suspect smoke detectors probably make houses a tremendous amount safer than they were before. It is probably safer to have a bedroom with no exterior exit, although I wouldn't recommend it, and a couple of smoke detectors in the house than it was to sleep in a house with an exterior exit and no smoke detectors.

KEMBEL: The problem with smoke detectors is that they are mechanical and so many times people do not maintain them, especially the battery operated ones. They have found that people unplug them or that the batteries are worn out; so it is a mechanical means that can be overridden. The problem also with the exit window, it is not only for the safety of you to get out but for firemen to get in. Now when you are underground it is not only an excellent place

to live as far as temperature goes, it also holds heat from fire very well. You can get a superheated air condition so that no one can get to you at all. Our furnishings within a house are probably the worst hazard, for instance, plastics. The chemicals that come off them are extremely deadly. I heard a story the other day that was kind of shocking. Two electricians were working in a vault of a building, a fairly new building. One of them somehow shorted the surface wires and I think three feet of insulation on those wires burned off instantaneously, killing both of them. They couldn't even get out of the room. That is how toxic some of that junk is. They vacated the building for three or four days before they could use it again.

QUESTION: Is there any environmental code agency in the state that governs siting, the effect of private homes on terrain, etc?

KEMBEL: I think the only thing that we have is the subdivision control regulations that are monitored by the Health Department. They monitor the environmental impact of the subdivision rather than the individual dwellings. And that depends on the size of the land you are developing. I think it is twenty acres must be approved, an EIS being done and all that. Individual home sites probably would have no controls. More and more they are looking at controlling for earthquake purposes, because of the faulting existing in this area. Another big one that is at issue right now is forest fires: The Pattee Canyon Fire is a prime example. We've got subdivisions where you can't get in with fire equipment or the people can't get out. If that fire starts up into the canyon, you are just dead. In a lot of cases you can't even run away from it.

COMMENT: I didn't quite understand what you meant by an alternate exit or two exits within a house.

STERLING: The provisions state that if you have two completely separate exits from a bedroom, you don't need to have a direct exit to the outside through a

window. There is an example in our book that I think is somewhat reasonable in this respect. In this case there is a garage at the back here and then a solar atrium which is an unheated but greenhouse sort of space. There is a living-kitchen-dining area that forms one large open room, so they satisfy all the codes. Two of the bedrooms are up front so they have direct access to the outside. This third bedroom which is on the back here doesn't have an exit directly to the outside. It doesn't meet the letter of the uniform building codes, but it would meet the HUD minimum programs. If a fire started somewhere in the house, you have two alternate exits. If the fire is in this part of the house you could come out through sliding glass doors onto the atrium, across and out of the garage this way without ever entering into the smoke filled part of the house, and vice versa. The exits have to be divided enough so that a fire couldn't cover both exits when it first begins.

RAY STERLING: SECOND SESSION — Downstairs

LOU MOORE, DNRC: There is a gentleman here this afternoon who is in the process of building an earth sheltered house. I would like to start out by having Terry Savage explain his problems in getting a loan and maybe shed a few insights as to what the problems are.

SAVAGE: I've been trying to finance an earth sheltered home -- I call it a subterranean home -- for about two years. It's been very difficult. I have gotten varied responses from lending institutions in Missoula. Typical response was the first response from the Federal Land Bank: a letter sent from the bank to their architectural section in Spokane said in essence, "If you have any questions do not call us. I'm afraid this is a real long shot." When you talked to them eye to eye, they were pleasant enough, but that's the way it usually went. Still, I have had some degree of success. I have taken my plan to FHA and received favorable response and FHA insurance through their 233 Program. I have received long-term financing through Charlie Morgan. Once I got my long-term financing, I thought I was on my way. But that wasn't quite the case; I had to turn around and get a construction loan. Going back to the lending institutions I was facing the same thing as when I started out. I received negative responses from almost all the banks in the Missoula area, even with the FHA commitment. The few banks that said they would like to finance don't have any money. There was one bank down in Hamilton which said they might do it but they tied some stipulations to it that I didn't like: I had to get a Hamilton contractor -- and I live 120 miles from Hamilton -- and do all the work at their bank. I'm not sure I would do it again as it has been frustrating and emotionally exhausting. I stuck with it and am still sticking with it. Another point I had to fight with the bank: the residence will not be hooked up to public power. It will be the first house not hooked up to public power

that FHA has ever approved. I'll have my own hydroelectric generator. It will be 100 percent independent.

QUESTION: Any difference in response between savings and loans and banks?

SAVAGE: No difference. In all fairness to the institutions, I am not building in Missoula; I am building near Superior which is 60 miles out. It is an easy out for them to say that is not in our lending area. So I asked if I moved to Missoula would they finance it. The answer is still no. They need to spend more time going into details and understanding and they don't want to spend that time. They can earn more bucks spending the time some place else.

QUESTION: Was this will full engineering backup?

SAVAGE: Yes. I had all the engineering details available.

JACK MOORE, Appraiser: Are you building this yourself? I don't know your background.

SAVAGE: I have a general contractor's background. I have built a half dozen homes. I will be acting as the general contractor, but will not be doing the building.

JACK MOORE: What about bonding? Would the lenders consider that?

SAVAGE: I have not tried to get bonding; no lender has asked for bonding.

JACK MOORE: If you were doing business through a well known local contractor -- and had significant bonding -- I would think that they would take off on it.

SAVAGE: As far as going to the local contractors I will be the general contractor and the subs will all go to local contractors.

LOU MOORE: One thing we did not touch much on earlier are the ventilation and plumbing problems.

KEMBEL: You have to have windows for natural ventilation or mechanical systems of some sort to ventilate the area. As far as fire exits, they require each sleeping room to have an exit directly to the outside. That could be done through

a window or door. An alternate method would be to provide separate corridors -- separate from the regular exit out of the house. Plumbing: probably your biggest problem would be to get the sewage up and out if the sewer lines are higher. You would have the problem of a sewer pump or ejector system.

STERLING: Most of the designs aren't any further into the ground than a conventional house with a basement. In fact, in some cases it may be less because you tend to balance the cut and fill so that you dig down a little bit and use the rest of the earth to mound up around it. So in an area with normal sewer depths and a normally designed earth sheltered house, I don't think you will run into any problem. If you are out a ways, then you are not going to be dealing with a sewer line anyway so I don't see too many differences from the sewer point of view.

QUESTION: These clivus multrums or any other composting toilets: What do the Department of Health or building codes say?

KEMBEL: If it is a good proven system I don't see that there would be that much objection. If there is gray water, you would have to go through septic tank rules unless it were a completely self-contained system.

STERLING: If you are separating the gray water out from the toilet functions, it generally leaves your house at quite a high temperature. When you cut the energy use of the house down to levels that you will with an earth sheltered house, you will find that quite a large proportion of the energy you have been using is going out of your house via the hot water that you use. If you have the gray water separated, it can become quite economical to use that water as a source for a heat pump to work off of.

QUESTION: Does that cause problems with septic systems working properly?

STERLING: It's like a fireplace flue: you're losing alot of heat unnecessarily. I think the septic system would work. But I don't know the level of heat you

can take out of it.

QUESTION: How do banks react to the kind of proposals the legislature is funding in Minnesota?

STERLING: The demonstration project was basically put through by the conviction of one state legislator who happened to be in a very strong position to provide the money for the demonstration program. I think they did a smart thing when they put the program in the hands of the Minnesota Housing Finance Agency, who really didn't want the program. They were somewhat skeptical but now are quite enthusiastic about it. We have noticed that people that get involved with it get to feel quite impressed by the whole idea. The program has two parts: one for three homes for state parks and the other for builder/contractors, who have to find their own financing and then also have to sell on the marketplace, so that there will be somewhat of a market test. Now, with the state parks, the DNR did not really want these houses either. The only thing they were really glad about is that they were getting some houses they didn't have to find the money to build. When we started, the houses were called solar/earth houses, and park officials would only refer to them as solar houses. The fact that they were going to be earth sheltered just wasn't mentioned. Gradually, as the projects have gone through the design stage, people became more familiar with the concept. By the final design meetings they were saying "Couldn't we push this down a little bit more because you can still see it from the road?" It was a complete turnaround from the beginning. The same with the Housing Finance Agency. The only thing they said they would do is to bring some pressure to bear on the banks. They wouldn't provide the financing. But they obviously do large dealings with some of the bigger banks, like Northwestern Bank, and so far none of the builder/contractors have had trouble getting financing, probably because it is a well-controlled demonstration project. I think the

banks have a lot to gain in terms of publicity from it as well. Individual banks are a very mixed bag and I think that is the case all over the country. John Barnard was a trustee at the bank he got a loan from, so he had no problem. Andy Davis' cave house was financed by his local bank, no problem, and that's as odd a structure as you're going to find anywhere. The availability of financing also depends on the amount of your down payment. Federal Land Bank in Minnesota has been very enthusiastic about providing loans in rural areas to earth sheltered homes.

QUESTION: Do you offer help in designs, etc?

STERLING: What we would like to do is to start compiling a list of banks that are favorable to looking at earth sheltered housing. At the moment, the size of our center and the volume of our inquiries is such that we just can't get into plan review -- absolutely impossible. We can barely keep up with the correspondence.

QUESTION: Any earth sheltered housing units in Montana that you know of?

COMMENT: One in Butte. COMMENT: One on the York road. COMMENT: Two on the road to Great Falls. COMMENT: One that some fellow has been working on for ten years and still looks like ten more.

STERLING: Banks have been financing walk-out basements for years. A walk-out basement is really an earth sheltered house. And it doesn't usually have the waterproofing that an earth sheltered house does. Just the word underground has such a bad connotation. Some people who have got financing just said they were building an energy efficient house, a little bit of earth on top for insulation. It may be clear enough on the plan but the fact that they don't go in there and say I'm going to build an underground house doesn't set up those initial hackles.

QUESTION: Has a committee set up insulation standards recently in the State of Montana?

KEMBEL: It wasn't a committee. Our department has just adopted model energy standards for new building construction, which is based on ASHRAE 90-75. There has been a lot of debate as to why we picked that standard and there are several reasons: The legislature did not fund or provide for developing an energy program. We had no money and the duty to do it by a certain date. The second thing was that in the few meetings we attended the federal government strongly pushed the model energy document for use by state governments. It appears now that they are doing an about face on us and are drafting their own, now that this one is being adopted by 16 or 17 states. So I am not sure it is the ultimate answer -- lots of people were exceeding it before it was ever adopted -- but it has been in effect since February 28, 1978.

QUESTION: Is there some clause in it that forbids the counties to go stronger than that on their building codes?

KEMBEL: The state law that was passed last session did make a state code a maximum and minimum code so that the local jurisdictions are to use only those codes adopted by the state. The reasoning behind that was to get uniform code enforcement across the state. You would be surprised how many communities have little special things within codes that supplement special businesses in their towns and that is just not the way codes should be written. So the maximum/minimum clause was written in. I would hate to see it dropped because I have seen places where zoning ordinances outlawed metal buildings because they didn't raise the evaluations for taxes enough.

QUESTION: How do you reconcile the fact Farmer's Home has gone to higher insulation?

KEMBEL: You will have to ask the Feds that, because they told us this is the code we are probably going to be using as a model. We adopted it. And immediately after that we had the new standards for insulation from FHA.

QUESTION: Farmer's Home has adopted these higher insulation standards but has Federal Housing adopted them, too?

KEMBEL: I've heard that, but am not positive of that.

JACK MOORE: The new Federal Housing code is out but it is not in effect until all the publications are out. The Farmer's Home Administraton's more stringent standards were thrown out in court and they are back down to HUD's standards which are FHA standards and they will all three be using the same standards.

KEMBEL: That is the R-38 standard?

JACK MOORE: Yes.

KEMBEL: All federal agencies were represented at that meeting and backed the model energy document, except for HUD which was a little hesitant. We were led to believe that we could be more or less blackmailed into using the model standar

QUESTION: Are you aware of any underground houses that are built of material other than masonry?

STERLING: Yes, they can be built out of most of the common building materials: unreinforced concrete in a conventional house design of straight walls and floors. That's probably good for earth burials only up to five or six feet, which is also true of unreinforced concrete block. Pressure treated lumber -- wood foundation houses. The later are very economical -- depending on local supply conditions -- for one story construction. When you get over one story, the cost of the size of the wood members needed rises very rapidly. Heavy timbered beams have been used for the ceilings -- generally with less than 18 inches of earth cover -- and in that case they wouldn't have to be pressure treated because you have a full waterproofing membrane across the top. Also, the beams are exposed so if there was any leakage it would be evident without any chance for dampness and rotting in a concealed space. You can also get into the shell structures which can use either mesh reinforced concrete or more exotic materials

as they are in thin sections.

QUESTION: What about thermal mass if you go to some other material?

STERLING: You are paying somewhat of a penalty if you go to some other material. You are not able in the walls that are struck by sunlight to store the same amount of energy. It doesn't effect your thermal contact with the ground very much unless you put in large amounts of insulation. If you use wood you can fill the voids up with fiberglass insulation on the inside and then cover over with paneling or something which gives you a very well insulated space. But then you do lose some of the effects of the thermal mass around. There are some trade-offs there. We think overall it is better to have some contact with the thermal mass in view of the long-term performance of the house and the ability of the house to go without heat for long periods of time. If you insulate yourself very well into the ground you cut down on your heat requirements but you can't deal as well with passive solar inputs because your space will heat up rapidly. You won't be able to store the heat as well, and it won't function as well if you turn the heat off.

COMMENT: With a wood foundation you still have a concrete floor, with a minimum of 4 inches and could use 6 inches, which would provide thermal mass there.

STERLING: You can cut down on the structure requirements of the walls of the house by building a structure to the natural slope angle of the fill. The steeper the wall goes the more pressure you get on the wall and the stronger the wall has to be until you have the pressure of the vertical. By tipping it back a certain way you can reduce the structural requirements you need in that wall. One of the houses in the Minnesota competition attempts to do that a little bit on the back wall. It's a two story design and it has the back wall of the house raked, so that the structural requirements for that wall are considerably less than for a vertical wall. Now, that poses some interesting space utilization

problems but it also makes for some interesting spaces, too.

QUESTION: You mean the bottom of the wall is toed out?

STERLING: Right. So you have a stable slope angle. When you achieve that, you need no structure to make it stable.

Wood foundation is relatively new. It hasn't been around very long so there's still a certain amount of guesswork involved as to how long it will last. There has been some talk about the long-term toxicity and whether there are any leaching problems with the chemicals used in treating the wood. The concrete association is coming out very strongly that there is danger there and the wood foundation people come out just as strongly that they have done the tests which show that there is no danger.

QUESTION: How long will underground houses last?

STERLING: The underground house will undergo virtually minimal temperature fluctuations and therefore minimal deterioration, because it will be within the insulated envelope which is on the outside of the structure. It is not exposed to flapping in the wind; it is not exposed to ultraviolet degradation. You are using very stable materials and they should be very permanent structures. We should remember, though, when you design a house for passive solar, whether it is underground or not, that those particular areas are actually going to perhaps have more thermal cycling than the rest of the structure. You might have to make provision for movement between the parts of the structure that you want to heat up and cool down and the parts that are going to remain very stable in temperature.

QUESTION: Any advantages or disadvantages to the type of fill you use around the structure, say, glacial till as opposed to homogeneous soil? Do rocks have any detrimental or beneficial effects?

STERLING: I would say generally you want sand or gravel, something that is

easy to work with, that drains well, provided you are above the water table. if you are below the water table, you would want the reverse. You would want a clay because it won't allow much water to move through. You can put in a gravel backfilling material and a foundation drain so that whatever might come through could be drained off. If you tried to do this with sand and gravel in a high water table, too much water could come through to drain down.

QUESTION: I was thinking of thermal dissipation. You say it takes several months for the ground to heat up around a building. I wondered if there were any beneficial factors having glacial till with a lot of rocks.

STERLING: I'd say by far the biggest factor in that would be the moisture content, rather than the type of soil or rock. There are some differences in specific heat of the rock as opposed to the soil and thermal conductivity but I'd say the biggest factor would be the moisture content. And that is not particularly well understood. We have felt from the experiences in Minnesota and from some testing we have done that once you get about 7 to 10 feet below ground level, you can more or less dispense with the insulation. Some of the Southern states took us to task about that. They have had some bad experiences with things they have put in uninsulated underground. We don't know the magnitude of the problem. It looks like maybe the difference is that they were building in a very damp soil with perhaps some water migration past the structure and were losing a large amount of heat that way. We think possibly what happens in Minnesota is the ground freezes on the surface and then gets snow on top. If you are above the water table the ground dries out quite a bit during the winter from the heat from the building. That then acts as quite an effective insulator.

QUESTION: Don't you have to be quite careful when you design the surface configuration so you aren't setting up currents that are coming down into an open

well or something like that?

STERLING: You should always try to have a flow away from the house; you don't want any water flowing in towards the house. If you are on a side slope you would make a swale around so that surface water is diverted around the house. If you have a fairly flat site and you need to have a courtyard and the ground slopes away, the only water you are going to pick up in that courtyard is the water that flows directly into it. Even in a heavy rainstorm, that is not a tremendous amount and can be handled by drains in the courtyard.

QUESTION: I was thinking about wind problems.

STERLING: Usually a courtyard is more protected, though in certain conditions you can set up eddying in a courtyard. I don't think Barnard's house, which was set back in the trees, would be very applicable to a prairie situation because it could fill up with snow and present problems if it were the only exit. You would have no real problem if a secondary exit was available or the courtyard was just a visual amenity.

QUESTION: Is there any federal or state grant or loan program for an individual or agency who wishes to build underground?

STERLING: I don't think anyone has a special grant for underground construction like they do for active or passive solar yet. The Department of Energy is presently developing what they call an innovative structures program, which is going to be primarily earth sheltered construction. But some of the higher ups aren't sure that it is much more than a fad yet, although the people involved in the program are quite enthusiastic. They have been planning the program for about a year. The funding for the entire program for the entire country is going to be $200,000, which is barely enough to send out announcements. But I think that the program will grow. There is going to be a problem in providing grants to earth sheltered housing. Pretty much all the federal

programs in those areas only provide for the extra costs over and above whatever the other costs will be. If you are buiding an earth sheltered structure and it costs the same amount of money, you are basically asking for money because you are taking somewhat more of a risk than if you build a conventional structure. They don't have any mechanisms now to make grants on that basis. They only make grants for the demonstrable added costs. There is the 233 Program which underwrites loans on houses, experimental ones. We hope to get HUD to accept earth sheltered housing as more normal than experimental. I was surprised to hear Terry say that construction financing was his problem because that has been the other way around with most of the people I have talked to.

QUESTION: Any favored water proofing material?

STERLING: The costs vary according to the application, particularly when you have a spray-on material vs. a sheet material. If the structure is simple so that you can use large sheets such as butyl, which is a relatively expensive material, that can actually turn out to be economical. You have very few seams, which is where the main problem is. On a house construction site you can probably watch pretty carefully that the membrane does not get punctured between the time you lay it down and the time you backfill over it. If you can do those things, a high quality sheet material is very effective. The other quite effective materials are the bentonite clays which are available in panel form or a spray. Bentonite is quite good because it is a clay that expands on contact with water and forms a jell. You put it on in a 3/8 inch thickness around the walls of a house and then you backfill against it. Then when the dampness activates the bentonite, it swells; the higher the water pressure against the wall, the less permeable the bentonite is. With any of the membranes, if you get a puncture the water can go through the membrane and can run along

the building until it comes through the weak point of the structure. So when you get a leak you don't know whether the leak is there or someplace else and traveling. That is what makes finding the leaks expensive. The bentonite material adheres to the structure and can be applied directly to the structure so it can't travel behind. If you have a leak, you know exactly where it is. Sometimes they can fix it from the inside merely by drilling a small hole through and putting some more material on. So they can offer a guarantee with the system. The disadvantage of the system is that as with any spray-on system you have a quality control problem; you have to make sure you spray all of it. Spray is a little more sensitive to the rain before it is backfilled, but a little better than the panels. The spray-on requires an applicator while you could nail on the panels. When the applicator comes out on just a small job you get a disproportionate amount of cost on labor.

QUESTION: How does using bentonite and then insulating over work?

STERLING: You just put the insulation panels up against the bentonite and then backfill. The insulation panels function as a protection for the waterproofing so it reduces any chances of puncturing the membrane. Actually, with the bentonite there is no such thing as a puncture of the membrane because if a rock pushes in there the bentonite will squeeze in.

JACK MOORE: Has there been any earth sheltered homes resold?

STERLING: The one in New Mexico that I showed this morning apparently was resold. People sold it because of the incessant inquiries. I don't have any information on the resale.

JACK MOORE: What is the situation with renting commercial properties? Do they have to rent at a lower level to overcome the objections to it? Or did you find any objections to it?

STERLING: In Kansas City they rent for considerably less than the going above

ground rate but they rent that way because it costs less and I think they are building up the demand. Space comes to them virtually free and they just run in some lights and some other utilities and they are all set; the space is already heated to 55 degrees F year around. Most of the other large scale buildings that have been built underground have been built because of space requirements. Monsanto headquarters has a very large underground cafeteria. I am not familiar with ones in commercial areas. Daytons has built an earth bermed home furnishings store in Minneapolis.

JACK MOORE: Were these built as a follow-up to adjoining buildings or to use a natural cave or were they designed specifically as earth sheltered?

STERLING: Most of the ones built on the college campuses were designed because they already had a campus there and they needed more space. At Kansas City mining has been going on since the turn of the century, and it is only in the last 15 to 20 years that they have started to use the space that was generated.

QUESTION: What kind of ownership exists with these Kansas City mines?

STERLING: In that case, they do own the above ground space. One thing they are planning to do is to sell off the above ground space with the title to the property cut off at a certain level below ground. There are some legal rights problems here. A lot of mineral rights don't specify who gets the space that is left after the mineral is taken out. I don't think there are any tremendous problems in setting out some sensible legislation with respect to this but it is going to affect some things that have already happened.

DON STEPHENS: FIRST SESSION — Downstairs

QUESTION: What do the tree roots do to the concrete when you start growing trees on top of your house?

STEPHENS: Roots tend to seek water and as long as you don't design pockets of water into your house, there shouldn't be too much difficulty with roots. The biggest difficulty is getting proper soil depth for the plant materials that you are using, and this is a matter of good judgement. In other words, you don't plant redwood trees on top of six inches of earth. Some designs have had earth wells coming down through the structure to draw on the soil below the building.

QUESTION: What about mulching?

STEPHENS: You should add mulch and sand to get proper drainage. We use light mulch for aeration and for drainage. A lot of times if we are only going to want light ground cover over a structure, say only grasses, we may go down a foot and lay in a double layer of reinforced Visqueen or other plastic, first putting another foot of very light material below that, so the wet soil is never in contact with the roof membrane at all. It gives an extra layer of protection. I treat underground design very much like above ground. A dead level roof underground doesn't make any more sense than it does on the surface. I always try to handle drainage in such a way that when it does come out onto the surface, it can reach percolation basins which will let it back in so that we aren't really disturbing the areawide water situation at all. I think Wells has explained this business of torrential floods everytime it rains, which are caused by having the whole surface area paved over like a parking lot. That is something I am always trying to stay away from.

QUESTION: Do you use Visqueen as a waterproofing material?

STEPHENS: Not normally, no, but it does work as a barrier to reduce the amount of moisture penetration of the earth directly adjacent to the structure;

this is pointed out in the charts. The drier the soil is, the less heat loss you'll have through it. You can do the same thing on the soil around the structure. On occasions we have literally tented around the structure so that we could divert water away from the wall surface, leaving the earth between relatively dry. The water goes down to tiling and drains out.

QUESTION: Do you use gravel aggregate on the roof to increase the rate of waterflow off the roof? Do you place the perimeter drain tile right next to the foundation or away from it?

STEPHENS: We have used a variety of materials to speed up the drainage off roof surface itself, not completely eliminating the water holding ability of that soil but speeding up the rate at which it moves out and into percolation areas, so that we don't get unnecessary loading. You can have an awful lot of sudden weight on a roof by having a fairly saturating downpour. Another factor that comes into my designs because I design for paranoids is fall-out protection. They feel that there is the possibility of some sort of a childish nuclear exchange between nations. If this should happen their home is their bombshelter, so they want membranes to keep water flow away from the earth directly over the structure. In other words, it will be a sandwich which involves roof structure, a layer of earth, waterproofing layer, and then additional soil. The bombshelter books say three feet of earth will protect you but if the fallout which settled on the earth's surface has percolated down and is sitting on top of concrete then perhaps you only have four inches of concrete shielding. In reality you are very vulnerable.

QUESTION: How thick do these walls have to be? What kind of materials do you use?

STEPHENS: A lot of it has to do with soil characteristics. If you have a high slough soil, it is going to need a lot of viable transfer, especially on a hill

slope. You must design for a great deal more movement than if you were berming against an above ground structure. Generally speaking, we don't find that we have any different situation than you have with typical basement construction. All we are really talking about in most cases with an underground house is a daylight basement. In a few cases where we want to increase the wall thickness in order to increase the thermal mass, we go to rubble concrete type construction, so that we are increasing the mass without increasing the amount of concrete. (There is usually plenty of on-site stone or whatever.) In terms of materials however, the big new thing is wooden formed construction for basements of conventional houses: this has been used for underground structures for about fifteen years now. I know of an all wood underground house -- well waterproofed -- which has had no trouble over an extended period of time, and has a life expectancy comparable to houses above grade. Of course, the temperature situation is much more even, humidity pretty level, so there isn't nearly the thermal movement one encounters with above surface wood construction. One of the things that several people are exploring -- Bill Egelman was the one that got me thinking that direction -- was the idea of using some of the heavy timber type construction. It seems to me if you were building underground with tongue and groove premilled logs, for example, using the proper sealant and insulation on the outside and then close tension on those vertical walls, you would get as much stability as from concrete, but with much lighter construction. If you are dealing with a site where it is not practical or easy to bring in a concrete truck, it might be far more wise to choose the wood rather than mixing concrete on site and having very inconsistent concrete mixture. It has been assumed that we have to go concrete but not so. The only drawback to wood is that we will be back to combustible structures which seems frightening until you recall that most of us live in them today.

QUESTION: Is there a minimum or maximum of soil coverage that should be placed on the roof in relation to R values of soils?

STEPHENS: It depends on characteristics of the soils and drainage and what your exterior temperatures are. Typically we have come to use two or three inches of foam on roofs and then as little as ten inches or as much as three feet of soil, depending on the soil. When you get beyond that the only reason you need it is for planting over. Most houses are not so big that trees can't grow on the sides and can stand over them and provide shade and shelter. You do have to consider lateral root pressures from trees. That is a real problem in the same way that it is with basements of conventional housing.

QUESTION: With your Visqueen and gravel tent do you use a waterproofing on the structure itself and what do you use?

STEPHENS: Definitely. What we use depends on the conditions. Originally we were just working with built up asphalt; lately we've been playing around with some of the sheet or liquid membranes -- butyl rubber, urathane, and so on. If you can go the cost, these are obviously the safest and the best way to go. I think you need to remember that basically we are designing dinosaurs; within probably 25 to 50 years what we are doing today will really be ancient technology. So although the structure itself might well last 1000 or 2000 years, the chances are that we will be doing some retrofitting and modification. I don't think in most cases we are designing a house to last several hundred years. I would guess that most of them will but I don't lose any sleep over the fact that it may spring a tiny leak in 75 years.

QUESTION: Why do you say these will be dinosaurs?

STEPHENS: I am speaking from personal prejudice here, so don't take it as gospel, but I would guess that by and large the active solar house as we know it is already a dinosaur. There may be effective active solar systems in the

future but I feel that the technology is progressing so rapidly that what we are doing today will be considered overly complicated, overly troublesome and underefficient even two years from now. An example of this would be the air type solar collector where we were trying to preserve efficiencies and calculate on that basis, when someone comes along and suggests we throw aluminum shavings from machine works into the air flow area and spray it black, and realize significant increases in heat output. So all of a sudden those hollow air collectors are obsolete, and this has happened just in this past year. The same way with underground construction. I am sure as the volume grows we will come up with factory modules that you will take to the site with the rebar all installed and the beams formed in so that when you get on site all you do is pour concrete over them and seal them and move in. I think that some of the things Ray was mentioning like pre-designed inflatables over which we'll use spray concrete which will reduce materials are very likely to be a common trend in the future. We may come up with some rigid plastics that will obsolete the idea of concrete entirely.

QUESTION: Have you used bentonite for waterproofing?

STEPHENS: I haven't personally. I have encountered it to a degree. Bentonite does offer a lot of potential for that sort of thing. I guess I tend to overprotect. In my situation most of my clients are financially able to afford to put a little extra insurance into it and because they are very cautious individuals to begin with, they would rather go that little bit of extra cost. We have used bentonite in the concrete to make it more water resistant and then gone ahead and treated it as if it wasn't done, adding layer of security on top of layer of security. Then, too, I've used bentonite over the membrane so if there is a break, it can flow in and stop it off.

QUESTION: If you have to design parapets, is there some material you can back

them up with to deal with freeze-thaw action?

STEPHENS: If I am going to use a parapet design, I basically use a moisture dam which leads back away from the surface. That is, catching the flashing with a waterproofing element, bringing it back, forming it out with wood, filling the interim space with vermiculite or the like that isn't ever going to get wet. As a result you won't have the frost-heave situation. So what you get is a cleaving type of arrangement where if the soil is going to move it's going to just thrust itself upward rather than back against the parapet. If you go to either wood or to something like vermiculite that is slightly compressible, it will absorb some of those pressures.

QUESTION: How do earth sheltered houses handle earthquakes?

STEPHENS: Fortunately or unfortunately, I haven't had a structure go through a major quake. I designed two or three that experienced some side effects from the Los Angeles quake with no consequence whatsoever, other than shocks that passed through and the vibration was felt, but no structural damage. In earthquakes lateral shifts seem to be the main problem with small construction. The ground is moving and the structure does not have time to move with it; you don't have that problem if you are in the ground. You can also have the problem of lifting and dropping if you happen to be directly over or in the center. In that sort of situation, you will have some temporary impact loading on the roof, but if you are designing for a possibility of a bulldozer backing onto the roof while he's backfilling, which you generally encounter when building anyway, you shouldn't have that much of a problem because the loadings are not that huge. I would say from an earthquake standpoint underground structures will tend to fare better than anything on the surface; wood on the surface usually fares pretty well and masonry does not. In terms of other calamities: for hurricanes, unless you are in a position low enough so that the hurricane pushed water into

your house, you are safer; they are natural tornado shelters; with proper design, fires -- forest fires, wild fires, brush fires -- burn directly over them; vandalism and theft are minimized. From most of the conventional hazards, assuming you used good sense in selecting the site, you are pretty well off. I wouldn't recommend building on the bottom of a slide area or an avalanche area unless you plan to stay there for an extended period of time. I wouldn't recom-emnd building any permanent structure on a flood plain.

QUESTION: Do you use insulation under your slab?

STEPHENS: I am all for insulation. Even during the warmer months in my solar greenhouse, I had trouble with heat loss through the soil until I insulated. You are dealing with a pretty large mass which takes a long time to warm up. My feeling would be to minimize that warm-up period. On that basis I am very much in favor of insulation, because we might very well have a warm-up period structurally of two to three months during which time you are pumping in August-September warm air at little cost except fans to move it in and out. On the other hand, if you are trying to heat up the earth to the vanishing point which may be ten - fifteen feet down, your real warm-up period might be a period of four or five, maybe even ten, years. On that basis you would have to oversize your heating equipment to begin with and have that extended warm-up period before you got to a point where you were getting relative stability.

QUESTION: How long?

STEPHENS: Depends on soils and on moisture and many other factors. You can talk about air conditions with a lot more knowledge than we can talk about soil conditions. I'm trying right now to gather information on temperature fluctuations in potato cellars which have been an underground structure in south Idaho for many, many years. But trying to get that hard information is amazingly difficult because the time when agriculture became more scientific and started doing this

kind of measuring was also the time in which energy was so cheap that they stopped building underground potato shelters and put up tin buildings on the surface and refrigerated them at tremendous energy consumption instead. Now they are beginning to go underground again. As yet I have not located a source of that data. It may exist or it may be something that needs to be done. But it is that kind of a problem; we are dealing with soils that are so variable that is seems to me the best insurance is to lay that insulation under the slab and not have to worry about it. I'd say this is true of everything, not just houses; swimming pools should also be insulated below. People insulate the top and forget that they are losing heat to the 45 degrees F soil all summer long.

QUESTION: What about resale value? The appraiser seemed negative this morning.

JACK MOORE: He didn't mean to be negative, just honest. We work with market analysis of past sales instead of future. We have market data that we have accumulated and to that we apply factors or adjustments to appraise a new building. The question is, of all these that you have designed and built, how many have been resold?

STEPHENS: I can't answer that as I deal with a specialized clientele. I know of some that have been resold, and resold for above the average growth factor of above surface construction. The round house shown in the morning cost about $35,000 and has had an option to buy at $65,000. It was only finished about four years ago. I don't know terms of lease. It's hard to use this as a basis. My own impression of the trend of the market is that a year or two from now, anything I designed or built would go for twice what my client had paid for it. What is going to happen twenty years down the road is going to be difficult to tell.

A generality I could make about the building industry is that there is not

enough interface like the kind we have here today: between architect, conceptual designer, builder, appraiser, lender, the whole bunch. We need to get together and do some communicating. I have seen far too many beautiful architectural monuments that were unliveable because the architect did not listen to the client's needs. There have been many houses that cost twice as much as they need have because the architect didn't sit down with the builder and ask what was a realistic way of doing something. And certainly there have been many instances of people building their heart's dream and then having to sell it later at a ghastly loss.

JACK MOORE: Mr. Kind looked at the situation conservatively this morning but he is basically positive and is very interested as many assessors are. That is why we are here today; we want to learn, too. We are not out to shake a project before it starts; we want as much fact and market data as we can possibly get.

QUESTION: How are bankers looking on this kind of project?

JOHN MEANS: We just had an underground house approved by the bank. But there are a number of reasons for it. It is in a popular area; resale of homes is well established in this area. We spent $1200 for engineering drawings. We also got a grant from the state. We built up a fortress of evidence. The bank also loaned us money on a solar heated house two years ago but again we had lots of evidence. We had a grant from the state again. I had built a house previously which resold for considerably more than it cost us.

STEPHENS: General rule: lots of documents and establish rapport in advance. If you know the banker, say "Hey, I'm thinking about this. I want to talk to you when I have a really good presentation." This will get him thinking about the subject, since he's probably not familiar with underground housing at all.

QUESTION: Do you have any idea as to cost comparison? I've heard estimates from 10% less to 20% more for a conventional house of the same square footage.

STEPHENS: Until we can get a builder to build two houses side by side -- one underground and one on the surface -- both out of concrete and all this kind of stuff, we won't know how much is the fact that it is below the earth. The building I showed you in Wyoming with a sod roof is a relatively conventional above ground construction but it has dirt on the roof. It would be interesting to know what the bid comparison would have been had they been putting asphalt shingles on it. There are some definite advantages to the earth cover that result in probable savings both short and long term in the cost of the roof. Apart from that, engineering wise, adding a little more beam to a building is not generally that expensive unless you have some sort of oddball design. It is quite common in commercial structures. For example, in Spokane there is a bank that is just opening which is two or three stories high and is designed to go eight later. That was quite feasible given present construction costs. So if you are talking about loadings and so forth, it is only a little more cost. On the other hand, you are going to a very minimal surface exposure so you will save a great deal on exterior materials. You're going to have a little more cost in landscaping unless you just go native. You get the airconditioning and heating sized down; much of what we have in a conventional house is really unnecessary. If you find there is a slight increase in cost per square foot, it is many times easier to stick with your dream and reduce your square footage a small amount than it is to abandon it and build a monster on the surface. Most of us live in a house that is far bigger than we really need anyway. I think you could cut a foot from the length and width of every room in the house except the bathroom and hardly notice the difference.

There is a scare factor involved in estimating the cost of an underground house. We did a study one time when I was in school where we took a house design and did an absolutely complete set of architectural drawings on it and

then we did a very rough plan set like the kind one would buy from a plan service. And we did about a ten page spec that basically said over and over "To Standards of the Trade"; and then we did about a ninety page spec which specified the size of every piece of gravel and every piece of wood and the grade of everything in the house and we took it to builders for bids. The result was that we found that exactly the same house depending on whether it was presented very technically and formally or in conventional building fashion could reflect in a 200 to 300 percent increase in the "contingency factor". We also found that with the figures for the architect designed house (that was the one which scared them), the high figures ran almost 100 percent higher than the low figure. So when you throw something new at builders, you have to explain to them the similarity between what they are doing and what they are familiar with. Basically, all we are talking about is a daylight basement and instead of putting a floor on top of it put a roof on it. Almost any builder has built a roof and a basement, so it should be presented that way. Then the cost should be reasonable. But if you go in with something that looks spooky they have to necessarily put in a small judgemental error factor -- like maybe 50 percent to 75 percent -- and you can't blame them. If something scares you, your feeling is that I'd rather let Joe down the street do it.

QUESTION: Would you share some of your mistakes with us?

STEPHENS: When we started out we assumed the earth was insulation. It's like an architect assuming brick is a neutral color. You just can't assume earth is a neutral material. When we started out we had sweating walls. We also had some troubles when we moved into a house in mid-winter, trying to heat it up. We were well into the summer before we got the warm-up period completed. It didn't present a permanent problem but did present an inconvenience for the owners because they had to keep the place uncomfortably warm in order to heat

up the structure itself. Typically we all know that insulation goes inside and learning that we were wasting tremendous thermal storage by putting the insulation inside instead of out was a big step forward.

Flat roof construction is a mistake; the parapet is a classic. Fortunately, I came just that far from having a building go ahead with a parapet design in the very early stages without realizing what I was getting into with frost pressures.

Things that I consider mistakes today that are still being perpetuated are: the myth that you have to stick with concrete. There are much more practical and economical materials. In two structures that I'm designing now we have truss joists with just a thin cap of concrete for a roof; it's much more practical than going to very massive roof structures. If you want thermal mass why not put it in the walls and floor and in the fireplace element.

That leads to another concern: heating the structure. I think it is a mistake to design a building that is going to last for many, many years with a heating system based on a fuel that is going to be gone in ten or twenty years. I tend to encourage design so the owners can fully cover their heating needs with a renewable resource. Take advantage of the passive solar when you can get it, but design the system so it is really revolving around the renewable resource of wood because I think that is the most sensible. In places where dependable wind power is available that would make sense. One system that is being played around with by people on the coast is resistance heating drawn from wind.

What may well make today's house a dinosaur is the solar cell system within the next ten years which will make it possible for all of us to have our electricity on the roof and at that point we might want to turn back to electric. But a complement of that is to have a minimal heat loss.

QUESTION: What is the most effective lighting?

STEPHENS: No different than above ground. It's a matter of individual taste. You can do some far out things: for example, if you want to have stars all over your ceiling you can play around with fiber optics and pour them right into the concrete slab.

QUESTION: Is there any difficulty underground as compared to above ground with heat gain from lights?

STEPHENS: You are going to have heat gain either way and this is certainly something that should be part of your calculations. If you are going to great quantities of suncollecting skylights, you are definitely going to want to design so you can minimize these heat gains during a period when you don't want it. If you're going to go to high-level artificial lighting you have to take that into your calculations. If you are going to be in a too high heat situation, it's possible to build such things as earth tubes and that sort of thing to draw in cool air to replace what you are heating up with your lights and such.

COMMENT: My thought on electric heat would be that there are lots of small hydro sites where we have an excessive amount of horsepower. With your thermal mass underground, rather than to go into mechanical government and peaking you could go to a constant load situation and dump the excess electricity into the thermal mass and bankroll waterpower in the walls.

STEPHENS: You can store it deeply so it comes out very slowly over a period of time. It's much more durable than storing it in batteries and the like. I think one of the big things when you are counting on wind is matching your house to the site. One of the worst mistakes we have made in this country for as far back as I can recall is taking a building that was indigenously developed for one area and planting it in another one. Tile roofs can be a real problem in cold climates. Many of the things that we have built just don't make sense when you take them

out of their natural habitat. Design for the local conditions. For example, if you are going to build in a brush area, rather than building a conventional house and putting sprinklers on the roof and buying exorbitant brush area fire insurance, why not design a house where the fire can go right over the top of it.

DON STEPHENS: SECOND SESSION — Upstairs

QUESTION: I have one question on insulation on the outside of an earth sheltered house. Obviously banks would be looking at longevity. What kind of track record does any kind of exterior insulation have?

STEPHENS: Well, with the foam insulation we haven't encountered any real problems at all so far. It is my understanding that stress tests or tests under exposure conditions suggest that they will last almost forever in the protective kind of condition we are giving them. There has been some debate on the effects of water on one or another. And we are still not certain about all the informatio regarding this. Some sources say stay away from urethane foam because of water penetration; some sources say stay away from styrofoam because of water penetration. And so we generally use what Malcolm Wells uses: foam protected with a thin layer of marine plywood. That will protect it from the backhoe and accidents, from one thing or another of that sort. And we have not encountered any difficulties with it. Beyond that we have on many occasions used one or another of the waterproof additives in the concrete itself to avoid problems with the water attacking the insulation from the inside. Of course, usually the membranes bleed anyway, but we don't have any indications of failure. I don't recommend compressable insulation on the outside for obvious reasons. For an ideal choice I would probably go to glass foam, but that is a little expensive. If someone were designing a time capsule for the year 3,000 and it was essential to maintain absolute heat, temperature, and waterproofing, I would probably put it thirty feet underground and use glass foam insulation.

QUESTION: What would you use for a vapor barrier between the wall and the glass foam?

STEPHENS: I would still probably use butyl sheeting or 100 percent solid catalysis urethane; you could go to a double buytl sheeting if you wanted to.

We are really kind of guessing, but reason would suggest that conditions are so mild in a relatively even 40 to 50 degree climate underground compared to what we are putting building materials through on the surface that you expect almost indefinite lifetimes. You can look at things like styrofoam and see how long it will hold up lying out in the sun, and you can get a feel for the durability of the material. It'll discolor but the darn stuff will never go away. If someone has left some out in the environment where it is making things unattractive, it seems like it is there forever. I think when man is gone all that will be left is little chunks of styrofoam, styrene beads and aluminum cans.

QUESTION: You decrease the thickness of the insulation as you go deeper but do not eliminate it completely, whereas in the Minnesota study they recommended contact with the bare earth below seven feet, I think. Why?

STEPHENS: My own experience on some structures where we have gone down and not used insulation in the lower areas is we have had sweating on the interior walls to the extent that we have had to use special air handling equipment to keep a constant flow of air across those walls. The vapor is coming from air within the building itself. People do awful things in buildings: they bathe, they cook, water plants, all sorts of things which increase the humidity. So, disregarding what is happening outside, you do have a moisture situation inside the building plus for the first little while, if you have exposed concrete, it's giving off moisture. You are really talking about two theories of heat mass. One theory says we are going to use the earth for X number of feet outside the structure as part of the thermal mass and as a result have a longer warm-up period; another theory says OK, let us limit the thermal mass to something we can warm up in a reasonably short period ot time. It seems to me that it is preferable to limit that mass. If you have concrete wall structure, concrete floor structure, even assuming that you are going to a wood roof, you probably

have a pretty good amount of thermal mass. Most of my most recent designs also incorporate masonry fireplace furnaces and that ends up being significant thermal mass in itself. So I don't think its necessary to draw on the earth. The thing is that you do have an ongoing heat sink otherwise in the form of your floors, like for example in my solar greenhouse. Even in the summer, as soon as the sun stops hitting, within an hour or two, you walk out there barefoot and it is cold on the floor. The room temperature is very warm but the floor is cold and the heat is disappearing right down into the ground. Now that greenhouse has been there for three years and hasn't warmed the soil up enough yet to stabilize. So this is my approach to the whole thing. I think it is a matter of personal choice. Either one will work but you will have a longer heat up period without insulation.

I would carry it a step further. I would say that in this age of energy shortage it is time we start thinking about insulation not only from the air but from the ground for a lot of things. My pet peeve is the bathtub. Why in the world aren't bathtubs insulated. You crawl into them when they are the temperature you want and five minutes later you are in cold, dirty water. It's bad enough having it dirty without it being cold. Or take swimming pools. A person will put in several thousand dollars for the solar collectors to heat the water in a swimming pool; they'll put out another thousand bucks for an insulated surface to put over it when they are not using it, or perhaps even build an inflatable dome or even a permanent greenhouse type structure over it. But do they insulate the bottom? No. So in this part of the country, they are constantly losing their water heat through the concrete and down into that soil which is a temperature of 40 to 45 degrees. It is like poking a few holes in the bottom of your boat and expecting it to stay afloat.

QUESTION: Could a person put a swimming pool in an underground house and control

humidity?

STEPHENS: I have done several with hottubs. I have served as consultant on two different ones with swimming pools and in both cases I recommended significant changes in design to allow for humidity and evaporation. One of the problems you get into with a closed system swimming pool, above or below grade, is condensation. In other words, you have concentrated chlorine dripping off your skylights or whatever. A friend of ours in LA had a swimming pool with a bubble over the top of it. He overchlorinated before he put the bubble over one winter and all winter when you walked in that room and stood in that air for 15 minutes your eyes would get red whether you were in the water or not. It was a captured environment and so there is that problem when you get large water spaces underground. There has to be evaporation.

QUESTION: How thick a styrofoam slab do you use?

STEPHENS: We tried different things. I would say optimally we've been going to double two inch layers in the walls and three inches under the floor. We have gone to as little as one inch in the walls and two in the floor and there hasn't been significant difference. It hasn't been anything you can really say in the long run "Boy, we really made a mistake."

QUESTION: Do you rely on passive ventilation to get the humidity out, or are you going to use active systems to get the air exchanged?

STEPHENS: Yes and no or both or whatever. We try to schedule in such a way that we can start the warm-up period during the summer. We use mechanical ventilation to pull as much outside air in to warm up the structure and dry it out as possible; sometimes you get into a condition where the warm season is so short you don't get the structure really closed until it gets too cold to draw on natural heat. So it has to go in by artificial means, either with fireplaces or wood burning stoves temporarily installed or even such things as

as buntane burners to bring the temperature up. At the same time, you have to blow air through to dehumidify it. But the question of humidity also depends a lot on the people who use the house. If they have a lot of skylight area lighting, large growths of hanging plants, and they also happen to be the kind that love to simmer soups two or three days at a time and take a long shower, you can get into some problems. On the other hand there have been some people who keep their homes very dry just by their habits. Dehumidification is a matter of relating to that.

QUESTION: Have you ever heard of tip up walls? Do you see any problems in that?

STEPHENS: I can't think of any. Tilt up panels in many instances are built rather lightly and consequently would not give quite the thermal mass but that could be picked up elsewhere. It is easy enough to pour a thicker floor slab, for example, to complement a lighter wall. In fact, I would imagine we are going to see a lot of that kind of experimenting. For example, we may very well see tilt up panels with poured in place insulation inside of them; that is, you have an inch of concrete on the outside and then three inches of foam poured into a panel, making the panel much lighter. I think we will see a lot more of that. We've seen that sort of thing in the past to a degree. People have been building houses of concrete, putting hay on the outside and then pouring concrete over the hay. So, no, I don't see a tilt up system or any kind of prefabrication as being a problem.

QUESTION: What kind of sealers do you recommend.

STEPHENS: Now there are a variety of sealers and you can talk to the sealer manufacturers and get more data than I can give you in a week on exactly which one to use where. They're used to dealing with this on the exteriors of the above grade houses and commercial buildings, instances where the thermal differentials are so much greater, expansion and contraction are so much greater

and moisture problems are so much more severe than underground. You get the lake facing side of a concrete prefabricated building in Chicago on a cold windy rainy day and you have a situation which makes your undergrounder seem like a piece of cake in comparison. That is basically the whole theme of going underground. It is so moderating to the structure and to the people in it.

QUESTION: Can you tell us a cheap way of finishing concrete?

STEPHENS: Break it up into one foot squares and paint it a sort of brickish red and then you sign your name Frank Lloyd Wright on the outside. I don't know. I don't think the costs involved are that great. You may have a little more cost there than you can pick up someplace else. It is really a matter of what a person wants. Let's face it, a lot of people put in wooden floors and then put high priced resilient flooring or high priced carpet on top of it. If you don't care for the natural concrete, you can go to pebble concrete, you can go to hand placed river stones, but chairs don't sit very well on them. Most of the imaginative ways of treating concrete are not that exciting. Some of the dyes and stains give it a little more natural character.

COMMENT: I just read in the Building Design and Construction, a magazine or quarterly, where they build whole houses on just gravel footings. They are well drained, stable. It's like railroad tracks, which are built just on gravel, and last for a long, long time, even with all that weight and vibration.

COMMENT: They did build them in Harlowton on gravel foundation -- large apartments -- but I don't know how they are coming out.

STEPHENS: This is a good way to approach things, not to take as givens everything we have been doing the past 200 years or 1000 years or whatever. There has been too much missed technology because no one did say "Hey, do you really need footings or you really need this or you really need to be above ground or whatever." On the other hand there certainly is a lot of research that

needs to go into a home if you are going to be living in it. You may find, for example, that they were doing this only on certain kinds of soil and if you put in on a different kind of soil you might not get good results. I think this is a situation where you want to talk to a structural and soils engineer and find out what will happen in your case; because a lot of it has to do with how much footing you need.

COMMENT: FHA has a status quo system of how you build houses. A lot of things that they are doing are not necessary. There are better and less expensive ways of doing things, but it is really hard to budge a bureaucracy.

COMMENT: They do have an experimental housing program. I don't know what they are really doing.

QUESTION: Is the FHA person here or downstairs?

ANSWER: Downstairs. There are a couple of persons from FHA here and also a VA person somewhere. Don Inman from FHA and Dorothy Carpenter from VA.

STEPHENS: I think that all of us who have been involved with the whole thing have felt the frustration of too many specific standards instead of performance standards. If we can show that a certain thing will perform the way it is intended to, it shouldn't matter how you do it. The real problem is you are dealing with a bureaucracy; no one wants to be noted for having stuck his or her neck out. It is a lot easier for the individual to say we will do it this way and we won't discuss anything else, rather than to take a risk. In some instances, we have found ways of getting around it. There was an instance of a house that could not be approved as an earth covered structure, so the client engineered it such that in case enough dust blew onto that roof over a period of years it wouldn't present an undue load. Then it was approved and financed as an above grade structure that sat in between earth banks on both sides. The last time I drove by it looked like an awful lot of dust was accumulating on that roof.

So sometimes it is a matter of getting around the regulations. There are times that people would like very much to go to a Clivus with their toilet system but that is not acceptable, so they put in whatever is considered an acceptable standard system even though it is an unnecessary and expensive duplication. Idealistically they are willing to do that. A Clivus makes a very interesting sculpture and you can put one in somewhere in the house in case they are someday approved, and use it as a sculpture in the meantime. If you need a pit underneath for the receptacle, why everyone needs a wine cellar. I wouldn't direct anyone to go against the rules, but I have known of cases where it has happened. That is one possibility if you get too frustrated: you can always explore being a criminal. Probably all of us in this room have broken at least one law during the last 24 hours anyway.

QUESTION: Would covering the cement cause any problems for your passive system?

STEPHENS: I don't see it causing a significant difference. A rug would slow it down a little bit. If you think in terms of a rug as insulation why you find it is very temporary insulation. Again, insulation is only a way of slowing down the movement of heat.

COMMENT: One of the things that I have been told the mass did in the summertime was to take in this large amount of heat and to take it in quickly. If instead the light comes in the window and strikes a carpet or something, you get black body radiation. With rugs they're having problems with overheating in passive designs. I was wondering if an asphalt tile would be the same.

STEPHENS: It will have that effect, but you are going to have a certain amount of that kind of trouble anyway when you get to dealing with solar collection in your living space. This is why in a number of cases with my clients we have gone to a solar greenhouse, because the greenhouse can tolerate fluctuations and then transfer heat through under floor tubing or whatever into the house more gradually.

In short, there certainly is that problem. If you are insulating your floor it is not going to absorb the sunlight as quickly as if it were bare, just as color makes a difference.

QUESTION: What do you do with the ceilings?

STEPHENS: In many instances, especially if we are going to exposed concrete walls, I like wood in the ceiling. Again, it is like the carpet on the floor, it isn't going to take in heat as quickly so you are going to have a little more stratification. In some instances we counteract that with slow rotary fans to break down the air stratification. But from an acoustical standpoint and an aesthetic standpoint it is nice. The other thing is that a wood ceiling, say you use tongue and groove over some sort of a truss system or over even wood timber, why then you may not need to go to any concrete at all. Or if you want to, you can put a cap slab on it or even a sizeable amount on it, depending on your inclination. I haven't really noticed that much difference. I don't think a person should steer away from wood roofs. The other thing that is involved is that if you are talking about concrete roof structure, unless you figured another way to float it that I don't know of, why you are either going to have it precast and hauled in, which might prove impractical or expensive, or you are going to have to form it anyway. So you might consider just forming it in place and have that be your ceiling finish, then pour concrete over it.

QUESTION: What about the problem of stress, using wood underground?

STEPHENS: Basically, whether you are building a wood foundation for a conventional house or a wood wall for an underground house, the lateral stresses are about the same. You will get a certain increase of lateral stress if you have four feet of earth above the top but it is only a matter of degree. I have worked with a couple of clients where we've gone to purely wood structures underground. They haven't got the thermal stability of concrete, though. I am afraid I am a

concrete man, too, but I think a lot would have to do with how long you expect the structure to last. If you're talking about temporary structure to be used for ten years or so, I wouldn't have the same hesitancy that I would over a longer period of time. Wood does fail; sometimes when you think you have it designed for proper loads it still fails over time. All you have to do to see that is to look at some of the cantilevered Frank Lloyd Wright houses. There's a kind of interesting downward curve of their decks and so forth. They have had to go back and shore them up with steel. Wood is a kind of unpredictable material. You can have weaknesses in wood elements that you thought weren't there. Concrete is more predictable and I would say it is safer. And of course steel is the safest bet of all, budget permitting.

QUESTION: Do you have any rule of thumb that you use for how far natural lighting penetrates a room?

STEPHENS: It depends on the latitude and it is very easy to use sun tables to calculate the penetration.

QUESTION: That is for the actual sunlight, but then beyond that how far?

STEPHENS: That depends on the materials and the color of the materials. In other words, if you have a floor that is white concrete, light will carry quite a way back, depending on the strength of the source. It is one of those very abstract things. For example, I have a design that I'm working on now. People have been pressing me for years to develop a plan set for a standard house that you can just take and plug in. It is called the wedge series since basically it is wedges that go back into the slope of the hill. I have it calculated for this climate so with a depth of 26 feet the sun is hitting the back wall in the middle of winter. It hits the back wall because the front part of it is higher; it is a three level thing. The front is here, the back drops down some and the second story comes up. So you are getting light on the back wall on the

lower portion of it in the middle of winter at noon. And in summer with that same overhang you will get absolutely no sun in the house. The floor of that structure is designed with a drum floor, using drums embedded in sand with a brick surface. This is kind of a long term thermal storage system. These drums are filled with water. They're polyethylene so they should last forever without rusting out.

QUESTION: But how do you know if you have enough light?

STEPHENS: I think you could take a look at above ground structures and get a feel for that. In other words, if you are thinking about something like a 22 foot depth, find an apartment with a 22 foot deep room and see how bright it is on the back wall. See if it is something you can live with and in reality you will probably find that with reflections from the sun angle and all the south facing windows will give more light further back in the rooms than you will encounter in much shallower apartment spaces on the north side of the apartment building. If the room is 16 feet deep on the south facing apartment, then to get the same foot candle level on the back wall of the apartment across the hall, you would have to have a room that was only 6 to 8 feet deep. And it is a matter of personal taste as some people like a cooler, lower light level. If you have a white back wall and a fairly neutral medium color on the floor and medium colored walls nearer to the windows, you will get much less glare effect than if you had white floor and black back walls. It's a matter of interior decorating.

QUESTION: What about waterproof material?

STEPHENS: We use a barrier inside the insulation almost without exception. The type depends on the soil conditions and the budget and what the client's comfortable with. I think under most conditions there is no reason why the regular waterproofing shouldn't be quite adequate. It is like you would treat a

conventional basement. Let's face it, under normal conditions most basements don't have any problems, and we don't go to butyl sheeting for basement walls. There are conditions where you are going to have problems. If you have a spring directly uphill from your house on a slope, then you probably will be wise to consider a little extra protection. That doesn't mean that you are not going to be able to hold the water the other way but it is a matter of peace of mind. It depends on the client.

QUESTION: Where was the insulation on your drum floors?

STEPHENS: The insulation is under the concrete slab. The drums are sitting on top of the concrete slab, with sand filled around them and then a brick floor laid directly on the sand.

QUESTION: How much sand do you put over the drums?

STEPHENS: Just enough so that there isn't any nubbling of the floor. It is about 2½ inches. Now this is not an optimal transmission situation. I'm not sure what would be a better material than sand to put around them. Short of building a big water tank floor, it seems like one way of having a long term balance, a flywheel if you will. It is something I have been playing around with and I have talked with a number of people from the University of Idaho and Washington State, but it hasn't been tested yet. If you want to play with it, great! If not, then don't. But it offers some promise and it is more attractive to me frankly than Baer's drum wall which is aesthetically less inspiring. Also he's talking about bungs rusting out in five years and barrels in twenty and he is not sure exactly when. You know he will wait until he develops leaks before he fixes it. I would recommend people go to plastic before steel drums.

QUESTION: Ferro-cement is used extensively in boat building. Have you considered using it for roofing?

STEPHENS: Sounds like a great idea. Ferro-cementing is a darn fun sort of a concept. It wouldn't be all that unlike some of the things that Solare has done with his silt casting. Certainly, you could form your house out of earth and pour cement over it and then excavate. I haven't encountered a client that is interested in doing that particular type of thing but then my clients tend to be more conservative in their orientations. It is good to see a different element become interested so that we can have a little more delight and a little less concern with commodity only.

QUESTION: The cost of these houses is prohibitive. Why don't you try designing some thing cheaper?

STEPHENS: I could agree with that to some degree and I have toyed with a lot of possibilities for this. But I haven't had anyone come to me and want to pursue it. One of the least attractive elements in our modern economy housing industry is factory built houses; there is no reason on earth why we couldn't design undergrounders that were factory assembled and delivered to the site ready for the pour. Basically, what you would have is a completely finished interior of a house, perhaps with some temporary shoring until the concrete has reached its 28 days strength or whatever. But these would be laid in a group in the side of a hill and poured over. The steel could be factory placed. Everything would be factory done so that the labor costs can be kept down and get a greater degree of efficiency of materials and labor. It would seem like a great answer since the bottom end of the industry is one of the most desperate and needy places.

At present we put our least well insulated, oldest and most dilapidated monstrosities in the hands of low income people. They will be the last to be able to take advantage of efficient housing. It is like the business with the wood stove industry. People with means can afford to buy the better wood burning

stoves; those with low income who really need to burn are the ones that are left with the old barrel drum stoves that burn at such low efficiency that they spend all summer cutting wood in order to keep warm in winter.

QUESTION: I am not sure where you get the 10 or 20 percent increase in costs in the underground structure. I think my cheapest area or space is the basement. I think it is cooler in the summer and warmer in the winter.

STEPHENS: Those aren't my figures. I think that you take conventional construction as it is done in housing developments and I think with a little thought you can design underground with just as much accommodation for comparable figures, perhaps less. I see no reason why not. It really depends on what happens in terms of differences in wall treatment, differences in air handling, etc. But you are going to save in the mechanical area for sure. You are going to save on exterior treatment, you are going to save on roof installation and you are going to pay a little more for structure and waterproofing. So the things balance out. But I would agree with you that the 10 to 20 percent figure is a dangerous one to float around because it scares some people off that needn't be. I think if a person can afford to build a house at all they can as well afford to build an underground one as one on the surface.

STATE OF MONTANA

DEPARTMENT OF ADMINISTRATION

BUILDING CODES DIVISION

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THOMAS L. JUD
GOVERNOR

August 24, 1978

Dear Code Official:

I recently participated in a workshop on Earth Sheltered Housing sponsored by the Montana Energy Division, DNRC. Architects, engineers, appraisers, loan officials, contractors and individuals from all over the State attended. A major concern of the workshop attendees was how this unique building design could be built within the constraints of Montana's building codes. The growing interest in this energy efficient type of housing indicates that you as code officials should expect inquiries from professionals and the general public in the coming months.

The most important consideration is the health and safety of the building occupants. Earth sheltered construction does not usually allow for windows low enough to provide escape from bedroom areas in case of fire. Two separate exits from each bedroom would fulfill the same intent of the code as the window exits. Natural lighting and ventilation also require special considerations in earth sheltered buildings. Good mechanical ventilation and artificial lighting can provide adequate comfort and safety to the inhabitants. Again, it is necessary to consider what the intent of the code is as well as the adequacy of the ventilation and the lighting systems. Section 106, UBC, allows for the use of alternate materials and methods of construction in these areas so careful consideration must be paid to plan details.

The structural integrity of the building should be checked. There are many construction methods which will provide adequate support of up to two feet of earth. Design loads need special attention when there is more than two feet of earth on the roof of the structure or when frame construction is used. Waterproofing is another important aspect that must be considered. There are several good waterproofing methods, many now being used on basements. Then proper application of waterproofing materials is just as important as which materials are used.

There are substantial advantages to building in the earth rather than on top of it. First and foremost, the buildings are highly energy efficient. At a depth of 10', the temperature of the earth stays within a few degrees of the annual average air temperature. It is much easier to raise the temperature 20^{o} above the exterior than it is to raise it 80^{o}. The earth acts as a heat source in the winter and as a heat sink in the summer. Infiltration problems are reduced to a minimum. Exterior maintenance is reduced and the original character of the land is retained.

Interest in nonconventional, energy efficient housing, such as earth sheltered housing, is growing in Montana. Code officials can encourage this interest by providing expert advice on the design of safe housing. Some alternate materials and methods of construction may have to be used, but we must approach these requests with an open mind. Housing is changing. Code inspectors should be a positive force in this change.

Sincerely,

W. James Kembel

W. JAMES KEMBEL, P.E.
Administrator

EARTH-SHELTERED HOUSING WORKSHOP
July 13, 1978
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This organization publishes a journal called Underground Space, which is available from Pergamon Press, Maxwell House, Fairview Park, Elmsford, NY 10523 (Library $60.00/yr., Individual - $40.00/yr) or through membership in the organization - $30.00/yr. Membership request should be sent to the Association and NOT to Pergamon.

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